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The American Midland Naturalist

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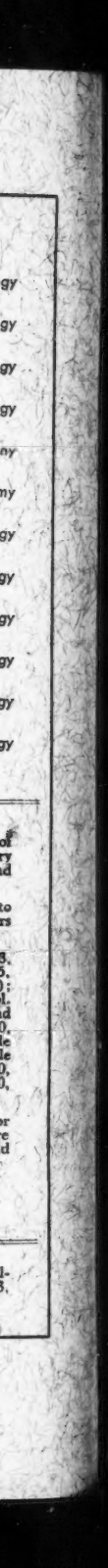

The American Midland Naturalist

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VOL. 40 NOVEMBER, 1948 No. 3

Faunistic and Ecological Studies on the Orthoptera of the Big Bend Region of Trans-Pecos Texas,

with Especial Reference to the Orthopteran Zones and Faunae of Midwestern North America*

Ernest R. Tinkham

Box 123, Indio, California

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* A contribution from the Lingnan Natural History Survey and Museum, Lingnan University, Canton, China, which under the directorship of Professor Wm. E. Hoffman, granted the writer the time to prepare the original manuscript. The manuscript was augmented by the addition of results from studies made in 1946.
revised during 1943-44 while the author served in the armed forces and in 1947 it was

Introduction

An excellent opportunity to study the orthopteran life of the Big Bend Region of southwestern or Trans-Pecos Texas presented itself when the writer was stationed at the Pink Bollworm Laboratory in the Rio Grande Valley at Presidio, Texas, during 1928 to 1930. During these two years all available spare time was devoted to the study of this region. Not only did the Big Bend Region prove to be a virgin field for the entomologist, but consequent studies have shown that its geographical location and orographic diversity have produced an exceedingly rich fauna and flora.

Prior to 1928 little study had been made of this region. The Davis Mountains and to a lesser extent the Chisos had been visited by various collectors and expeditions in the past, but the writer knows of no expedition or collector of any kind that had collected in the Chinati Mountains which served as his principal hunting grounds from September, 1928 to July, 1930, and again in 1931. Additional collections were made in the Marfa region, in 1940 and on the north side of the Davis Range in 1940 and 1943. Resuming his desert studies, in October of 1946, three weeks of collecting were conducted in the Chinatis and Chisos and other mountainous areas.

Presidio County with Brewster County on the east and Jeff Davis County on the north form the little-known Big Bend Region of Trans-Pecos Texas. The eastern apex of Brewster County on the Rio Grande is approximately 102° and the western tip of Presidio and Jeff Davis counties is about 105° West Longitude. The southern end of Brewster County on the Rio Grande, south of the Chisos, is about 29° and the northern apex of Jeff Davis County, north of the Davis Range is 31° North Latitude. Thus this area is of considerable size and roughly estimated contains 11,832 square miles or 7,573,760 acres, an area larger than such states as Massachusetts, Maryland or New Hampshire. In fact Brewster and Presidio are two of the largest counties to be found anywhere and each in size surpasses some of the smaller states of the Union. One can put in a full day of good travelling and yet remain within the boundaries of Presidio and Brewster counties. For instance the shortest route to the Chisos Mountains or to Castalon below Terlingua, from Presidio *via* Marfa, Alpine or Marathon is well over two hundred miles and much of that distance is over dirt or gravelly roads.

Possibly few regions can boast an area more diverse than these three counties. Not only do they portray interesting topographical and orographic features, but within the hundred miles from the Davis Mountains to the Rio Grande at Presidio, the floral aspect is one of extreme contrast. In that distance one passes from the pine-topped peaks of the Davis Range down through a zone of junipers and oaks to the grasslands, across broad level grasslands to the desert mountains, the Chinatis, with pines, oaks and junipers and lechuguilla, sotol and ocotillo at lower elevation and thence across the creosote-covered mesas to the mesquite valley of the Rio Grande. Another transect running from north to south through central Brewster County would pass from the forested slopes of the Glass Mountains, across the Marathon Plains into creosote-blackbrush desert, thence to more eastern semi-desert type of vegetation represented by *Leucophyllum* and *Porlieria* just north of the San-

tiago Mountains and across the creosote mesas south of the Santiagos to the magnificent Chisos. Here one would climb almost vertically through the oak zone to Pulliam Bluff and Mt. Emory, at 7836 ft., to find forests of pines, Douglas fir, Arizona cypress and various oaks. The descent would be as precipitous from the peaks to the creosote mesas of the Rio Grande near Mariscal Mountain.

Since the proposal in 1938 and the erection in later years of the Big Bend Park formed around the magnificent Chisos Mountains in the southern end of Brewster County, the public has manifested greater interest in the Big Bend Region which truly is the "last wild Texas."

As no complete work is available on the flora or fauna of this particular region, the writer believes that he is justified in dealing more fully with the various aspects of the region than would otherwise be warranted. Furthermore, a thorough treatment of physiography, climate, and the ecological aspects of the flora of the region are essential prerequisites to a comprehensive survey of the orthopteran fauna of the Big Bend Region.

Physiography of the Region

The Big Bend Region of Trans-Pecos Texas is traversed by two parallel series of ranges representing what may be called the terminal fingers of the Rocky Mountain system. These two series of disrupted sierras appear to have their origin in the Guadalupe Mountains of south central New Mexico, for south of Guadalupe Peak, that stupendous rampart known as El Capitan, this range appears to break up into two groups, the Delawares and the Sierra Diablos. The Delawares continue southeastward through the Apaches to the Davis Mountains which occupy much of the northern portions of the Big Bend Region with lesser ranges such as the Glass, Del Norte, Santiago and Dead Horse Mountains continuing on to the southeast (see fig. 1 for location of mountain ranges, etc.). The Sierra Diablos run south through the Van Horn and Tierra Viejas, to the Chinatis and the Bofecillos of Presidio County, and on to the San Carlos Sierras of northern Chihuahua. Chinati Peak, the highest point in Presidio County, attains an elevation of 7760 feet, only slightly surpassed by Mt. Emory of the Chisos with 7836 feet elevation. The Chisos Mountains in the southern part of Brewster County and lying within the apex formed by the "Big Bend" of the Rio Grande, do not appear to belong to any system but stand out in their isolated grandeur of rugged perpendicular cliffs. For years both the Davis Range and the Chisos were claimed to have the highest peaks in Texas, but the award finally went to Guadalupe Peak with an elevation of 8751 feet. Mt. Livermore in the Davis Range, 8382 feet above sea level, is the highest point in the mountainous Big Bend Region. But for noble grandeur of mountains, the superb majesty of the Chisos, with their castled peaks, is incomparable.

The trough lying between these two systems of disrupted sierras is in Presidio and Jeff Davis counties—a level far-stretching grasslands which extends itself fingerlike into and through the valleys of the Davis Mountains. In Brewster County the trough is broader with the Marathon Plains merging on the south with desert lands.

In this entire region one is never out of sight of the Sierras, and aside from the grasslands, the physiography of the region is exceedingly rough. The basin floor is often rolling and rocky, except in the Valentine, Marfa and Marathon areas where the soil cover of the grasslands is of a rich alluvial type. The mountains of the Big Bend Region are exceedingly rugged (with the possible exception of the Davis Range) with cliffs, steep slopes strewn with boulders and talus, rocky ridges and prominences, buttes, volcanic peaks and rock-walled pinnacles cut everywhere by innumerable gorges and valleys of all dimensions; for the greatest of all dynamic forces, water in the form of the

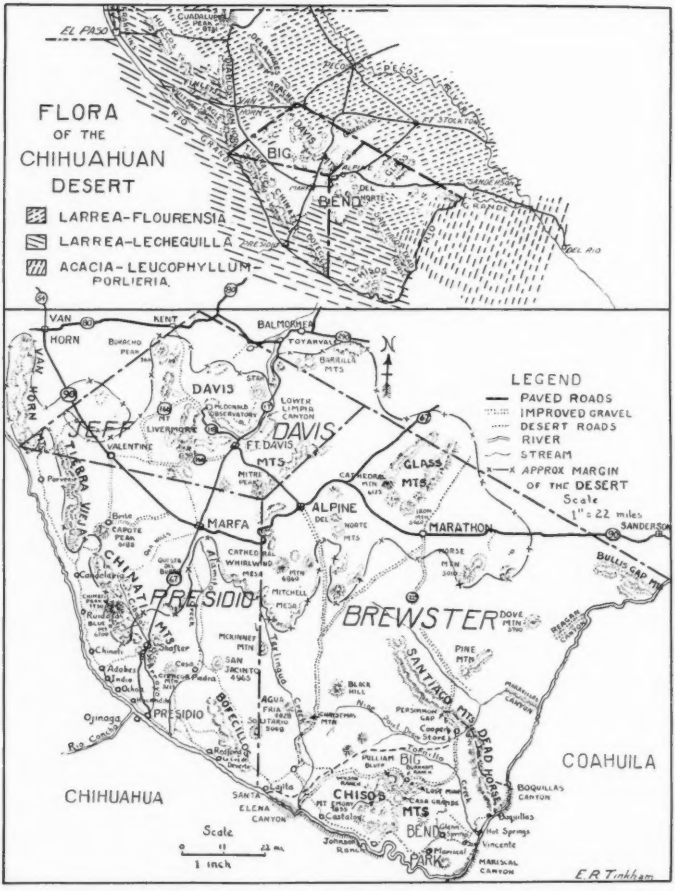


Fig. 1.—Trans-Pecos Texas showing the Big Bend Region (upper) and map of the Big Bend Region (lower).

torrential arroyos, has been working unchecked throughout the ages, mitigated only by the scarcity of water itself. In fact the desert regions of the Southwest present a tremendous area of soil erosion, abetted by the over-grazed lands of ranchers who make little effort to check the destruction.

Climate of the Region

The climate of the Big Bend Region is arid to semi-arid in type and shows considerable variability according to location and altitude. The Davis Mountains receive the greatest annual precipitation, totaling about seventeen inches, while the Rio Grande Valley from Presidio to Castalon gets the scantiest amounts, averaging about eight inches.

There is a great irregularity in the storms which come from all directions but in general these follow along the mountain systems, such as the Chinati and the Davis ranges. At Presidio from November, 1929 to June, 1930, only traces of rain fell, totaling 0.97 inches for eight months, while the Chinatis received at least four or five inches. On one occasion, the 8th of June, 1930, the writer was in one of these torrential showers which proved to be a veritable cloudburst, and yet despite its severity, one could step from wet to dry soil where the storm crossed one of the mountain tops.

An indication of the greater frequency of storms in the Chinati and Davis Mountain regions, north of the Valley, is evidenced by the frequency of the arroyos rolling down their torrents to the Rio Grande. The Cibolo Arroyo draining the northern slopes of the Chinatis and passing through the mining town of Shafter, often rolls its waters past Presidio, sometimes doing considerable damage to the west end of that town, while Presidio and the Valley receive not a trace of rain. Similarly the Alamito, six miles downstream from Presidio and draining the Marfa Plains and part of the southern slopes of the Davis Range, often comes down like a mighty Amazon when the Cibolo is dry, thus proving the greater prevalency of rains in the Davis Mountain region.

These arroyos, like the impounded waters of a reservoir when a dam gives way, carry everything before them. That these are not idle words is well proven in the floods of September and October, 1932, and again in September, 1936, when on account of the severe storms in the western Sierra Madres of Chihuahua, Mexico, the Rio Concho, with its confluence with the Rio Grande at Ojinaga just above Presidio, came down with such floods and violence that it inundated the entire valley. Damage to the cotton crop, destroyed buildings and bridges and other property amounting to hundreds of thousands of dollars.

The greater part of the annual rainfall coming as it usually does in the late summer months (Fig. 2) though sometimes earlier in June or May, brings the plant life into resurrection and makes the Marfa-Davis Mountain region a veritable paradise of green pastures.

The Marfa and Ft. Davis regions, which range in elevation from 4800 to 5200 feet or more, have much cooler summers and more severe winters than the Rio Grande Valley. One can always notice the changing temperature upon leaving the Chinatis above Shafter, at about 5000 feet elevation, and gradually dropping across the creosote mesa to Presidio at about 2700 feet elevation.

If it is winter, the additional warmth will be welcome, but if it is summer the change is one of stifling heat.

The twenty-second of December, 1929, brought the coldest weather experienced in decades (Fig. 2). The Valley recorded a minimum of 9° F. while the Marfa reports were considerably lower. Snow remained on the ground at Presidio for over a day, a very unusual occurrence, and on the 30th the writer found snow in the shade of cliffs in the Bofecillo Mountains, 30 miles east of Presidio. This extreme low temperature killed the flowering stalks of *Yucca Torreyi* that were commencing to bloom on the desert at this time, although normally they did not bud until March.

Usually, however, as in the winter of 1928-29, when only five mornings registered temperatures as low as 22° F., the minimum usually occurred at dawn. The diurnal fluctuation in the Valley is great, many days showing a range of 40 or 50 degrees or more, so that by 5:00 P.M. the maximum temperature may be 75° F., or 53° above the minimum as in one recorded case. When the sun goes down, the temperature rapidly drops, especially in winter. This is due to the sparse desert vegetation and the nature of the desert floor which is covered by a layer of gravel or cobblestones and forms what is called the "desert pavement." As soon as the sun has set, the heat in the desert pavement rapidly dissipates into the clear dry atmosphere and the temperature drops rapidly to reach the minimum at dawn.

The maximum temperatures at Presidio occurred on June 25 of 1929 and 1930, with 113° and 110° F., respectively. A second hot spell occurs usually in early September, when a temperature of 105° is not uncommon, often ranging to 109°. July and August temperatures are somewhat mitigated by the occasional summer showers.

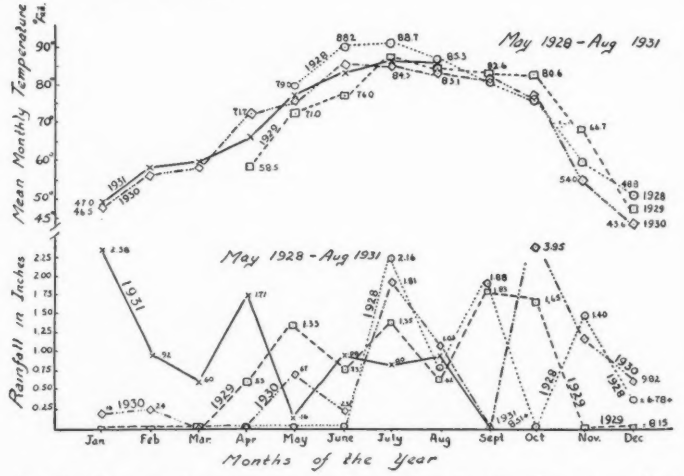


Fig. 2.—Mean monthly temperatures and rainfall at Presidio, Texas, from April, 1938 to September, 1931.

The mean annual humidity is very low and during the year the daily minimum occurs around 4.00 P.M.; the maximum at dawn. During the hot dry spells of summer it is a common occurrence for the hygroscope to register below ten and sometimes zero humidity. Only during the rainy spells, which seldom last for more than three days in the fall, and in late October to December at dawn when very heavy dews drench everything like a shower, does the humidity ever attain maximums of 90 and above.

Air movement is slight with only gentle breezes blowing during the greater part of the year. The period from October to February and sometimes March is usually calm and beautiful with clear skies and balmy days with a violet haze veiling the distant Sierras and making these months one long glorified Indian Summer. In late February and early March sandstorms commence and sometimes continue as late as June, but normally end in April. These are often of great violence and at Presidio almost always come from a northeast direction.

The number of clear days during the year at Presidio total about 325, and a completely cloudy spell of several days duration is a rare occasion.

The effect of showers is seldom noticeable after a few hours on account of the dry air, sparse vegetation, bright sunlight and the barren desert pavement which has a very high run-off rate especially after heavy and sudden showers. The sunlight is intense and this region is indeed a land of sunshine and health-giving atmosphere.

Factors Affecting Vegetation and Animal Life

Over most of the Big Bend Region the vegetation has in recent decades been greatly changed almost wholly due to the overgrazing practices of man. Only in the more inaccessible and rugged mountainous regions does the vegetation retain any of its original aspects. The herds of goats that range over the foothills of the Chinatis prevent the attainment of the natural growth of the vegetation by their close and continued browsing, and in pastured areas their effects are much more intensified and destructive. The effect of continued browsing by goats in the desert foothills, such as those of the Chinatis, is not always apparent at first sight. One is prone to consider the vegetation of these foothills as short and sparse and natural for such areas but this is far from the facts. Continual browsing has been largely responsible for the erosion of the thin soil cover coating the limestone rocks. Naturally this erosion and continued browsing of new growth plays an important rôle in reducing the insect, bird, reptilian and mammalian life in these areas. The scarcity of butterflies, grasshoppers and other forms of insect and animal life is largely attributable to the work of the goats and sheep in desert areas. Let me illustrate. One of my favorite collecting spots was a small desert valley in the Chinati foothills, between two limestone hills, two and one-half miles south by the old road from the mining town of Shafter, Texas. In this valley I collected many rare and interesting forms during the period 1928-1931. When I again visited this valley in October, 1946, after return to civilian life, I found that the right-hand hill (looking south) had been fenced for some years. The change was remarkable. The vegetation was much denser and taller than that just across

the road on the unprotected hillside. The skeleton weed (*Euphorbia antisyphilitica*) formed the finest colonies I have ever seen (Fig. 12) and the many other desert plants were in the same improved condition. The rare acridids *Zapata brevipennis* and *Netrosoma nigropleura* (not taken previously in this valley) were not uncommon and indicated how important a rôle plant protection plays in restoring animal life. Not only is the fauna favorably influenced and increased by plant protection but the denser and more luxuriant growth reduces the forces of erosion and actually aids in the restoration of the soil cover. What has been said concerning insect life is equally applicable to bird, reptile and mammalian life, for with greater plant protection and abundance of plant and animal food all forms of life will ultimately be favored.

What has been said concerning the effects of goats browsing on desert vegetation is equally applicable and even more so to cattle overgrazing of the grasslands and marginal grasslands merging with the desert. This is the direct result of the stupid and blind folly of the greedy ranchers. Cottle (1931) has shown that snakeweed (*Gutierrezia*) is the principal invader and its presence not only indicates overgrazing practices of ranchers from Texas to Arizona, but snakeweed invasion presents a blacker picture, namely that of destroyed grasslands, ruined ranches and erosion that increases yearly to the ultimate destruction of all our valuable lands in the southwestern United States. Nor have the ranchers tried to check the forces of erosion, caused by their greedy overgrazing practices, with the reduction of herd sizes and dams to control runoff, but appear to be the most indolent of men permitting gullies to expand to large arroyos and washes under their very eyes without lifting a finger to stem the tide.

These considerations should be of vital interest to every wide-awake American citizen and it is time, long past time, that our people and government did something to check the ever-increasing waste of our natural resources.

Flora of the Big Bend Region

Floral Zones and Subdivisions

As yet no comprehensive work has been attempted on the flora of the Big Bend and large areas remain unknown and will probably remain as such on account of the inaccessible nature of these remote areas. Cottle's work (1931) on certain grassland areas of the Big Bend Region is undoubtedly the most notable of the earlier attempts to study the vegetation of this region. Since the completion of the writers first manuscript in 1934, the establishment, in 1938, of the Big Bend Park in the southern end of Brewster County around the nucleus of the magnificent Chisos Mountains, has stimulated interest in this splendid area. The formation of this park has eliminated the ranchers and perhaps in time the vegetation may regain much of its former aspect within the park boundaries. Studies are in progress by the botanists at Sul Ross State Teachers College at Alpine. Dr. L. C. Hinckley's work (1944) on the Mt. Livermore area of the Davis Mountains is a worthy achievement and that botanist is now (1946) engaged in the study of the flora of the Chinati Mountains. Because of our incomplete and inadequate knowledge of the Big Bend Region the following discussion will be somewhat detailed.

The flora of the Big Bend Region may be divided into the following groups and subgroups:

A. Lower Sonoran Zone represented by various types of desert flora.

a. Rio Grande Valley chiefly of mesquite.

b. Desert Mesa of various types depending on location. In Presidio County chiefly of creosote, ocotillo and yucca and ranging from the edge of the Valley at 2700 feet to the base of the Chinati foothills around 4200 feet. In southern Brewster County, south and east of the Chisos, the mesa is dominated by creosote and large clumps of *Opuntia Engelmanni* and *O. rufida* with some *ocotillo* and *Leucophyllum*. In central Brewster County the mesa has co-dominant stands of creosote and blackbrush (*Flourensia*) over wide areas and these range across the north end of the Big Bend, north of the Davis Mountains. Other mesa areas just north of the Santiago Mountains possess a vegetation typical of the Eagle Pass region and characterized by *Porlieria*, *Leucophyllum* and long-bladed *Yucca*.

c. Mexican Lower Sonoran flora characterized by lechuguilla, ocotillo, sotol, huisache, guayule and many other plants in the Chinati foothills from 4200 to 4800 feet elevation.

B. Upper Sonoran Zone represented by grasslands, oaks and junipers.

a. Grasslands of the Marfa-Alpine-Marathon Plains merging with desert vegetation on the south and east (Brewster County), and extending into the valleys of the Davis and Glass Mountains on the north where a savannah-type of oaks, junipers and grasses clothe the lower mountain slopes.

b. Mexican Upper Sonoran flora represents a type found from 4800 to 5500 feet in the Chinati Mountains and perhaps at a similar elevation in the Chisos.

C Transition Zone represented by pines, Douglas fir, cypress and certain oaks.

a. The northern slopes of Mt. Livermore in the Davis Mountains above 7500 feet or more; the northern slopes of Blue Mountain and Chinati Peak in the Chinatis, and certain high valleys and peaks in the Chisos forested with western yellow pine, Arizona cypress, Douglas fir, Chisos red oak and big-toothed maple.

It must be understood that these zones and their subdivisions are not sharply demarcated one from the other but almost imperceptibly merge or grade into each other. The areas of intergradation or transition from one zone or subzone to another is usually termed an *ecotone*. However each zone is distinct in itself and it is only the *ecotonic* area that exhibits a composite nature, a blending of two zones or subzones lying side by side. In mountainous areas these ecotones may be passed through by climbing several hundreds of feet up a mountain slope, and one zone may be observed to come down into another on a steep northern slope and the reverse occurs on southern exposures, but on flat ground ecotones may occupy a great many miles. A more detailed account of the flora of these zones now follows.

FLORISTIC ECOLOGY

A. LOWER SONORAN ZONE

a. *Rio Grande Valley Flora.*—The Rio Grande Valley lies between the mesa escarpments on either side of the river so that it varies in width from the actual confines of the river where the banks are steep (as below the mouth of the Alamito, six miles below Presidio) to a valley from one to several miles in width.

The soil of the valley floor is a heavy clay, called "adobe" which is light

to dark reddish-brown in color, very sticky when wet and fissured with cracks when dry. Where alluvial fans are formed by the numerous arroyos crossing the valley floor, the soil may vary from adobe to sandy or gravelly depending upon the type of terrain traversed by the arroyos and their size. These alluvial fans develop a flora peculiar to themselves on account of their soil structure and subsoil water supply.

The dominant plant of the valley floor, wherever adobe soil prevails, is the velvet mesquite, *Prosopis juliflora* var. *velutina,* which forms impenetrable thickets everywhere but which at present has been largely cleared to make way for the cotton fields. Associated with mesquite is the blue thorn, *Condalia lyciodes*. On the adobe flats intersected by small arroyos, mesquite and catclaw, *Acacia Greggii,* with its fragrant yellow catkins are found along the arroyos. All-thorn, *Koeberlinia spinosa,* is often found growing in large adobe mounds, the results of aeolian soil deposits. Along the sandy border of the Rio Grande and in damp sandy places, dense thickets of the Mexican jara, *Baccharis glutinosa,* abound. These flowering plants, willow-like in habit, are members of the Carduaceae and form the principal food for the colonies of Mexican beaver, *Castor canadensis mexicanus,* established in some of the ox-bow ponds of the Valley. Along the banks of former stream beds, cottonwoods, *Populus Fremontii* var. *Wislizeni,* and black willow, *Salix nigra* are found. Cattails, *Typha latifolia,* and reeds, *Juncus Torreyi,* find livelihood in these ox-bow ponds. Occasionally large groves of cottonwoods occupy river flats where the subsoil water supply meets their requirements. Mistletoe, *Phoradendron flavescens,* is a common parasite of cottonwoods in the Valley.

At certain places as at Indio and Ruidoso, respectively 16 and 42 miles upriver from Presidio, Tornillo or screw bean mesquite, *Prosopis pubescens,* is dominant where the soil is impregnated with alkali and in such places and elsewhere Bermuda grass, *Cynodon dactylon,* is common.

In the spring of the year and during the rainy season in late summer and fall, the adobe and arroyo flats are often ablaze with the yellow blooms of the woolly stemmed composite *Baileya multiradiata,* one of the characteristic flowers of the region. Jimson weed, *Datura meteloides* (with large white, morning glory-like flowers and long horned pods that Indians use in basket making), milkweed, *Asclepias* spp., and a loco weed (with large bladder-like pods) as well as other plants grow scattered over the Valley floor.

Near Ochoa, 12 miles upriver from Presidio, four-wing saltbush, *Atriplex canescens,* grows on alkali flats, often associated with the brittle joint cactus or tasajillo, *Opuntia leptocaulis*. These clumps afford splendid protection for the grasshopper, *Aeoloplus elegans,* which evades capture by jumping down into the midst of the spines. A yellow lily with rancid bulb buried deeply in the soil is found occasionally on these flats.

Near the edge of the mesa, creosote bush, *Larrea divaricata,* and ocotillo, *Fouquieria splendens,* are usually found growing on soil typical of the mesa.

Where large sandy arroyos cross the valley floor as a few miles northeast of Presidio, huisache, *Acacia Farnesiana,* and desert willow, *Chilopsis linearis,* of the family Bignoniaceae and narrow-leaved yucca or soapweed, *Yucca elata,*

are found. The desert willow with its lovely lavender-spotted white flowers, resembling large snap-dragons, line the gravelly borders of the arroyos. In large communities of *Yucca elata* growing in this vicinity, the brightly colored Scott oriole is found weaving its nest in the pendant leaves. Areas similar to these occur at Chinati, 39 miles upriver, with bluewood, *Condalia obovata*, creosote, ocotillo and *Baileya multiradiata* and other plants growing in rich profusion. Near Candelaria, 65 miles upriver from Presidio, certain sandy arroyos are dominated by *Yucca elata*.

In the wet arroyo as at the mouth of the Alamito, the Texas blue bonnet, *Lupinus texensis*, is often found blooming profusely in the early spring.

The plant life of the Rio Grande Valley in Brewster County is closely similar to that already described for Presidio County.

b. *The Desert Mesa Flora.*—The desert mesa commences as a low escarpment paralleling the Valley proper, at about 2700 feet elevation, at from one to several miles from the river. It gradually rises in elevation towards the base of the Chinati Mountains, some twenty miles north of Presidio, where it merges with the mountain slopes at 4200 to 4500 feet. Everywhere the gravelly "desert pavement" covers the adobe or gravelly subsoil and gives the mesa its characteristic appearance. Arroyos constantly intersect the mesa forming many stony-sided valleys of variable size.

The desert mesa is dominated by creosote with a general admixture of ocotillo and spanish dagger, *Yucca Torreyi*, which may in favorable habitats form dominant communities. Cane cactus, *Opuntia imbricata*, often forms societies and is certain to have an associated population of cactus wrens with them. Prickly pear, *Opuntia Engelmanni*, and the pin-cushiony masses of the strawberry pitahaya, *Opuntia stramineus*, with deep purple blossoms are found; the latter most common on the gravelly sides of the arroyo valleys and on knolls and hillsides. This pitahaya is diligently searched for in June, for its pink edible fruit with numerous tiny black imbedded seeds has a delicious strawberry flavor, so that the name "desert strawberry" is quite appropriate.

Here also are found other species of cacti such as the devil's pin cushion, *Mamillaria robustispina*, devil's head or bisnagre, *Echinocactus horizonthalonius*, with large deep pink flowers, rainbow cactus, *Echinocereus dasycanthus*, with huge orange-yellow blossoms that open fullest the second day, and the fish-hook cactus, *Neomamillaria microcarpa*, with its small coral-red fruits. Other rarer cacti include *Opuntia Grahami* of spiny prostrate form and with bright lemon-yellow flowers.

The rare and lovely night-blooming cereus, *Peniocereus Greggii*, with large fragrant flowers lasting only a night is found rarely in arroyo valleys. Its root is a huge tuber, about the size of a large turnip, in which it stores its food.

Candelilla or waxplant, *Euphorbia antisyphilitica*, occurs most commonly on limestone outcrops on hillsides and on the edge of the gravelly mesa where sangre de draco, or blood-of-the-dragon, *Jatropha spathulata*, is commonly found. The arroyo valleys have an admixture of such plants as mesquite, Spanish dagger, huisache, catclaw, bluewood or abrojo, *Condalia obovata*, and *Lycium Berlandieri*, with desert willow and yellow-trumpet flower, *Tecoma stans*, along

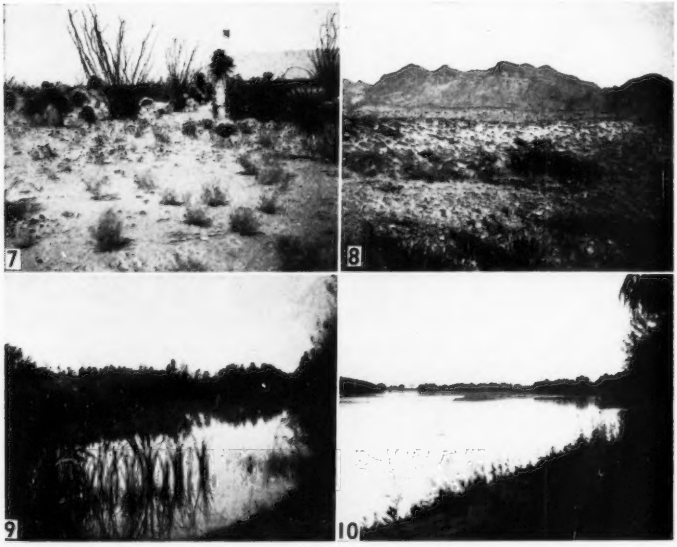
the stream margins. Often in the shelter of the creosote bushes, blossoming in the rainy season is the delicate blue-flowered *Commelina crispa*. Grasses are practically absent from the mesa. If the rains come in late summer or fall, as they are supposed to do, certain flowers such as *Baileya multiradiata*, *Cassia bauhinoides* and *Zinnia pumila* decorate the desert mesa with bright yellow and white flowers.

The mesa continues down the river to Lajita where the Santa Helena Canyon commences to cut its way through a tremendous rock escarpment. Southeast of Terlingua this mighty canyon, the "Grand Canyon of the Rio Grande" has its abrupt mouth for after cutting through solid rock to a depth of 2600 feet with sheer perpendicular walls, the river makes a sharp right-angled turn and follows at the base of this rock escarpment for many miles. Thus in Brewster County there is only one mesa and that on the American side of the river. In the Castalon area, the mesa is closely similar to that described above the canyon from Lajita to Candelaria, but southeast of the

Figs. 3-6. Vegetation types of the Big Bend Region.—3. Desert vegetation at Elephant Rock on north side of Chinati Mountains, six miles north of Shafter, Texas; 4. Marfa grasslands with scattered clumps of *Yucca elata;* 5. Heavily wooded canyon in the Bofecillos about 30 miles east of Presidio, Texas; 6. Wadi Burnham ranch house at north base of Chisos Mountains; Pulliam Bluff in center background, table top of Casa Grande in left background.

Chisos on the road to the Hot Springs and Boquillas the mesa assumes a different aspect. Here creosote, ocotillo, lechuguilla and numerous large clumps of cacti, *Opuntia rufida* and *O. Engelmanni*, occur with blood-of-the-dragon, and occasional plants of silver-leaf, *Leucophyllum frutescens*, which is the host plant of the grasshopper *Phaulotettix eurycercus* in this region. Travelling north along this road towards Marathon we find a new species of *Leucophylum, violaceum* described by Pennell in 1941, dominant a few miles south of the Boquillas-Chisos road junction.

The mesas surrounding the north base of the Chisos are dominated by creosote, lechuguilla, mesquite, ocotillo, *Opuntia leptocaulis, O. Engelmanni* and *O. macrocentra* and the dwarf yucca, *Yucca baccata,* and other plants. Some miles to the north the gravelly mesa is replaced by adobe soil and from here north for 20 miles to the south base of the Santiago Mountains and west of the Dead Horse Mountains, the mesa is almost a pure stand of creosote. Mesquite occurs in the washes and on bare adobe flats, in the fall, the rank-smelling, dwarf *Dyssodia polychaeta* makes golden carpets of flowers in the setting sun.



Figs. 7-10. Vegetation types of the Big Bend Region.—7. Desert vegetation of Rio Grande Valley near Chinati, looking northwest to Chinati Mountains. Ocotillo and *Y. elata* in background with the yellow composite *Baileya multiradiata* abundant in foreground; 8. Looking northeast across the creosote mesa to a portion of the Chinati Mountains just east of Shafter; Lechuguilla in left foreground; 9. Oxbow pond in the Rio Grande Valley at Presidio; 10. View of the Rio Grande at Presidio, Texas, taken from toll bridge.

On the mesa north of the Santiago Mountains after passing through Persimmon Gap, an intrusion of semi-desert vegetation, typical of the Del Rio-Eagle Pass region, is found. This mesa is characterized by creosote, the dark green clumps of goat-bean, *Porlieria angustifolia,* and *Leucophyllum frutescens* which on the 22nd of October, 1946, were mounds of large lavender-scented flowers and this species undoubtedly ranks as the most beautiful of the plants of the Chihuahuan Desert. Here also grew in profusion other plants; such as blood-of-the-dragon, strawberry pitahaya, tasajillo, honey mesquite, *Prosopis juliflora* var. *glandulosa,* blackbrush, *Yucca Treculiana* with long narrow bluish green blades, and others. Several miles north of Persimmon Gap the vegetation commences to change very gradually towards the creosote-blackbrush type of desert with other members such as the black-stemmed *Acacia constricta vernicosa,* mariola or *Parthenium incanum, Yucca Torreyi,* and *Mimosa biuncifera.* From 30 to 10 miles south of Marathon the dominant plants are creosote and blackbrush, *Flourensia cernua,* with some ocotillo and lechuguilla on knolls and with white-brush and abrojo in the washes. On a rocky ridge near a roadside spring, 12 miles south of Marathon many species of ferns were found in the rock crevices; such as *Pellaea cordata, P. atropurpurea* and *Pellaea* spp. and various species of *Notholaena* and *Cheilanthes.*

From this region the co-dominant stands of creosote and blackbrush extend north to the Carlsbad Caverns and from the Pecos River west to the Sierra Diablos and bordering the Davis Mountains on the north. Intrusions of this vegetational type break through the low hills at the west end of the Davis Range south into the western end of Presidio County west of Valentine. From the Sierra Diablos and Guadalupe Peak the creosote-blackbrush desert extends westward through southwestern New Mexico, at Hachita and Animas, and curves around the north base of the Chiricahuas to the San Pedro Valley and the Pierce region of southeastern Arizona. This type of desert characterized by *Larrea-Flourensia* may be recognized as the Pecos subregion of the Great Chihuahuan Desert. The Rio Grande type typified by lechuguilla-sotol vegetation extends northwestward up the Rio Grande to Sierra Blanca and the Franklin and Hueco Mountains and southeastward into Coahuila, Mexico. The lechuguilla-sotol type may be called the Coahuila subregion of the Great Chihuahuan Desert leaving the third type, the Salado subregion extending south from Carneros Pass, southwest of Saltillo, Coahuila, to Matehuala, San Luis Potosi.

c. *Mexican Lower Sonoran Flora.*—The lower levels of the Chinati Mountains are characterized by a flora here designated as the Mexican Lower Sonoran flora because its flora and associated fauna as well, is derived entirely from Mexico. Consequently many species of plants and animals find their northern limits of distribution on the North American continent in the Chinati Mountains.

The dominant plants of this floristic zone are sotol, *Dasylirion leiophyllum,* huisache or *Acacia Farnesiana* and lechuguilla, *Agave lecheguilla,* the latter dominating the limestone ledges of the foothills. The larvae of the giant skipper (*Megathymus mariae*) burrow in their roots and the pocket gophers

gnaw out the hearts of the plants so that there are always many dead and dying lechuguilla to be seen. On the gentle gravelly slopes at the base of the limestone hills, colonies of creosote, mariola or *Parthenium incanum,* and *Leucophyllum misum* occur with scattered plants among them of *Heliotropium angustifolium, Mortonia scabrella,* and *Buddleia marrubiifolia* with bright orange-red flowered and creased leathery leaves. The Mexican rubber plant called guayule, *Parthenium argentatum,* grows sparingly on the hill tops and its sap is quite sticky, drying into fine rubbery fibers. Spanish dagger and ocotillo are scattered here and there and with the other plants such as lechuguilla, sotol and huisache present a picture typical of this flora. Clumps of skeleton weed, *Euphorbia antisyphilitica,* are found on certain limestone ledges and these are favored habitats for the rare acridids *Zapata brevipennis* and *Netrosoma nigropleura* known only from this area.

In the shelter of rocks and in rock clefts and at the base of boulders where the soil moisture content is higher, a considerable variety of plants and flowers find a livelihood. Here are found yellow-trumpet flower, Mexican walnut, *Juglans ruprestis,* trifoliate barberry, *Berberis trifoliata, Linum Berlandiera* a flax, and *Hibiscus denudatus* and *H. Coulteri* with lavender and pale yellow flowers respectively. In the shade of large rocks and cliffs, the interesting *Forestiera angustifolia* with narrow linear leaves coming out in whorls from knotty stubs and closely resembling *Larix* in habit, is found growing with ferns such as *Notholaena sinuata* and *Cheilanthes tomentosa* and others.

Indian paint brush, *Castilleja latebracteata* described by Pennell in 1941, *Dalea formosa* the feather dalea with purple flowers, and *Psilocalyx Greggii* and various cacti such as the rare peyote, *Lophophora Williamsii,* living rock cactus, *Ariocarpus fissurata,* and others are found growing on the hilltops. On certain slopes, the resurrection plant, *Selaginella lepidophylla,* forms beautiful terraces, row upon row, which retain rain water and prevent runoff and erosion (Fig. 11).

In the valleys and along the arroyo beds grow a profusion of plants and flowers such as mesquite, catclaw, huisache, bluewood, and whitebrush, *Lippia ligustrina* with its tiny, white, honey-scented flowers. Climbing flowers are represented by *Janusia gracilis* and *Eupatorium Greggii* with its lavender tasteled blooms. *Baileya multiradiata* is also common in such locations. The foul wild gourd, *Curcurbita foetidissima,* is observed creeping across the sands of the arroyos on its long runners. In one particular valley, about two miles south of Shafter, a few plants of the blackbrush, *Flourensia cernua,* are found growing; the only ones known in the southern part of Presidio County. Despite the few plants its associated grasshopper, *Goniatron planum,* exists with them. Two other colonies are known to the writer, one 10 miles north of Marfa on the Ft. Davis road, and the other one mile north of Bunton Flat and about 29 miles north of Presidio. In Brewster County and north of the Davis Mountains blackbrush is co-dominant with creosote over great areas of the northern portion of the Chihuahuan Desert.

Grasses, which are rare in the Chinati foothill regions, include such species as *Muhlenbergia monticola, Bouteloua trifida* and *Triodia mutica.* At higher

Figs. 11-16. Vegetation types of the Big Bend Region.—11. Terracing effect and erosion control achieved by the resurrection plant, *Selaginella lepidophylla*, in the Chinati Mountains about two miles south of Shafter; 12. Fine stand of the skeleton weed, *Euphorbia antisyphilitica*, and favorite habitat of the grasshoppers *Zapata brevipennis* and *Netrosoma nigropleura* (Chinati Mts.); 13. Alpine grasslands looking north from a point a few miles east of Alpine, Texas, early January. A herd of 34 prong-horned antelopes are grazing in center of picture (Alpine-Marathon Grasslands); 14. Marathon plains looking south from a point ten miles northwest of Marathon, Texas, early January. Clumps of sacahuiste *Nolina texana* dot the center of the picture (Alpine-Marathon Grasslands); 15. Desert vegetation one mile north of Persimmon Gap on north side of Santiago Mountains showing *Leucophyllum frutescens* in heavy bloom (center) with *Porlieria angustifolia*, the dark plant (center foreground). Blood-of-the-dragon seen just above right corner, lechuguilla in left corner and stalk in right center; left of center are several stalks of *Yucca Treculeana;* 16. West base of the Dead Horse Mountains east of Cooper's Store with creosote in foreground and the Giant Dagger *Yucca carnerosana* center and right center and *Y. Treculeana* in the left corner.

elevations in the Chinatis, species of *Panicum, Setaria* and *Cyperus* in moist places, are found. These grasses have been identified by Dr. L. C. Hinckley of Sul Ross State Teachers College, Alpine, Texas, and Dr. Robert Darrow of the University of Arizona.

In other locations in the Chinati foothills many additional plants are to be found including such as *Bouvardia ternifolia, Cyphomeris gypsophiloides,* the purple-black pea, *Physalis atropurpurea,* and such rarities as *Acacia Schottii* and *Pentstemon Jamesi,* one of the few pentstemons growing in a desert environment.

Where water occurs in the larger arroyos such as the Cibolo at Shafter, cottonwoods and Mexican jara are found along their banks.

The remote and little accessible Bofecillo Mountains lying north of Redford and east of Presidio some twenty miles, are lower than the Chinatis but on account of the character of its limestone rocks and cliffs with grottoed caves and deep-walled recesses, the region assumes a different and varied aspect and provides shelter for a great variety of plants. Dense thickets of trees and shrubs, such as bluewood, cottonwood and mesquite, occur along the main water course, entangled with wild grape and creepers. In one rock-walled recess Texas ash, *Fraxinus texensis,* with other interesting plans was discovered. The plateau-like peaks and the rough mountain slopes are dominated mainly by ocotillo, sotol, lechuguilla and Spanish dagger, and in appearance are quite similar to the Chinati foothills and undoubtedly represent the Mexican Lower Sonoran flora.

B. UPPER SONORAN ZONE

a. *Grasslands.*—North of the Chinatis at from 5000 to 5500 feet elevation a series of hills such as the Cuesta del Burro and the Frenchman Hills slope off to the north in rolling fashion to finally level out on the Valentine-Marfa Plain.

This grassland represents the Upper Sonoran Zone and is dominated by various species of gramma grasses such as *Bouteloua gracilis, B. hirsuta, B. triopoda* and *B. curtipendula,* which are of chief ecological importance. Others occur, such as chino grass, *B. breviseta* and *B. chondrosioides,* as well as *Aristida pansa, Muhlenbergia* spp., and *Chloris virgata* which is usually common along road margins. Scattered over this grassland, especially in the Marfa area, are clumps of low bushes of *Microrhamnus ericoides, Rhus trilobata, Clematis Drummondi* and *Lycium pallidum.* Dense communities of narrow-leaved yucca, like dwarfed forests, slope gently off to the south from areas east of Marfa, to finally merge into the desert flora coming up the Alamito (Fig. 7). North of Marfa considerable all thorn *Koeberlinia spinosa* grows. Other plants include *Adolphia infestans,* a tall *Eriogonum,* the pestiferous snake weed *Gutierrezia Sarothrae, Buddleia scordioides* and *Michaerantherea tannasetifolia.*

Further south on the Marfa-Presidio road, where the country becomes hillier and rockier, the floral aspects change from one dominated by grasslands to one occupied by sacahuiste and sparse tall grass. Finally on nearing the Chinatis, sotols appear, often forming dense communities on certain knolls,

with Spanish dagger, ocotillo, lechuguilla and other plants present that are typical of the Mexican Lower Sonoran Zone. At Bunton Flat, some 40 miles south of Marfa and just north of the popular landmark called "Elephant Rock" (Fig. 3), a community of tobosa grass, *Hilaria mutica*, occurs, with a blackbrush colony one mile north of Bunton Flat.

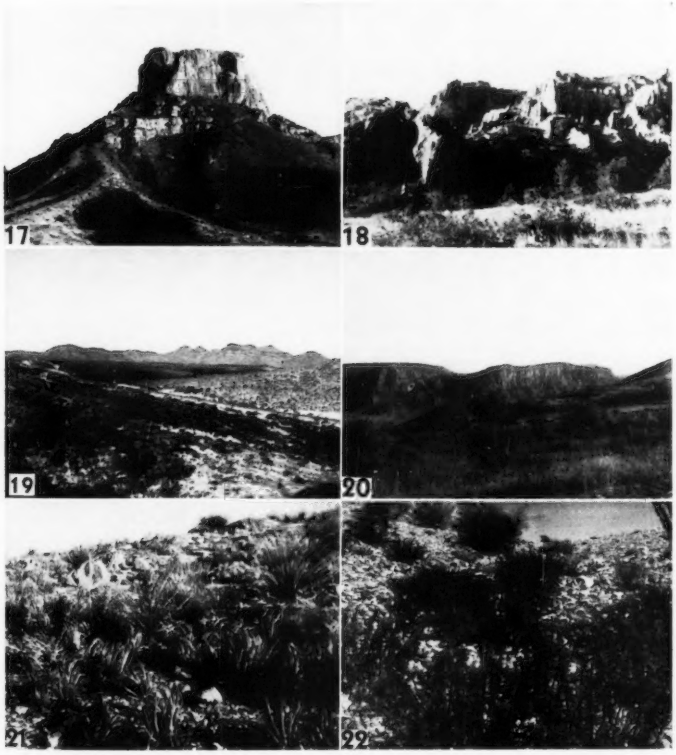
On their northern extremity, these grasslands ramify through the southern valleys of the Davis Mountains, forming excellent grazing range. Fine groves of live oaks, *Quercus Emoryi*, are located on the alluvial fans at the mouths of canyons and valleys while on the mountain slopes gray oak, *Quercus grisea*, Mexican walnut, *Juglans ruprestis*, merge with one-seeded juniper, *Juniperus monosperma*. Other trees, such as Osage orange, *Toxylon pomiferum*, with a great variety of grasses and other plants occur. Cottonwoods grow along the water courses, such as Limpia Canyon, where on south-facing slopes century plants or mescals, *Agave Wislizeni*, are seen growing. This plant is common further north around the Carlsbad Caverns and Pine Springs and their presence in Limpis Canyon indicates the infiltration of desert plants into the northern portions of the Davis Range.

The northern margins of the Davis Mountains show definitely a closer proximity to desert conditions than does the southern edge, which is grasslands. The northern border supports such common grasses as *Bouteloua gracilis, B. barbatus, B. curtipendula, Andropogon furcatus, Aristida ternipes* var. *minor;* flowers such as *Gymnolomia, Microsiphonia microsiphon, Amorpha fruiticosa* and *Tidestromia* and shrubs such as *Parthenium incanum, Lippia Wrightii, Rhus chloriophylla* and others. Scattered junipers, sotol and yucca are also seen on hillsides at the northern extremity of the Davis Mountains east of Kent.

East of the Davis Range at Paisano, where the mountains form isolated cone-shaped peaks clothed with oaks and junipers, the vegetation continues as grasslands through to Alpine and Marathon. East of there, acacias and other shurbs begin coming in until the grasslands have been practically replaced by desert shrubs. These have already been described for the mesa flora of Brewster County. Scattered junipers occur on the hillsides near Sanderson. Six miles east of Sanderson the elevation suddenly drops off into the Pecos Valley where the chief desert shrubs are creosote and blackbrush. Thus we observe that the grasslands of the Big Bend Region are ringed by desert on all sides.

East of Sanderson at about 15 miles west of Langtry, elements of the Tamaulipan Semi-desert Bushland begin to appear in such dominant shrubs as *Acacia Berlandieri, Prosopis juliflora* var. *glandulosa, Leucophyllum misum, Cercidium macrum, Porlieria angustifolia* and others. As already noted elements of this flora are found on the north side of the Santiago Mountains and as we progress eastward it becomes more and more prominent. It is this flora that brings into eastern Brewster County and the Chisos Mountains a number of faunal elements which are not found in the Chinati Mountains. These include cockroaches, stick insects, mantids, certain grasshoppers and katydids as well as cicadas and other forms of animal life. On the other hand the Chinatis have many Mexican forms not found in the Chisos.

b. *Mexican Upper Sonoran Flora.*—Elevations in the Chinati Mountains roughly between 4700 and 5500 feet represent an ecotone between the Mexican Lower Sonoran flora with its desert shrubs, and the grasslands above 5500 feet elevation. This zone is called the Mexican Upper Sonoran flora and con-



Figs. 17-22. Vegetation types of the Big Bend Region.—17. View of Casa Grande from the Chisos Basin, late afternoon. Slopes covered principally with oaks (Chisos Mts.); 18. Craggy south slopes of Pulliam Bluff as seen from the Chisos Basin. Late afternoon sun is shining through "the Window" to reveal the rocky ridges in shadowy relief (Chisos Mts.); 19. View of valley two miles south of Shafter; vegetation of lechuguilla, sotol, huisache, skeleton weed and many other plants on limestone hillsides with mesquite, creosote, bluewood, whitebrush and a little blackbrush in the valley; peaks east of Shafter in the background; 20. Lower Limpia Canyon about six miles northeast of Ft. Davis (Davis Mts.); 21. Dense stands of lechuguilla, *Agave lecheguilla*, on limestone slopes about two miles south of Shafter, Texas (Chinati Mts.). Upper left is *Acacia Farnesiana* and sotol center and to right; 22. Edge of the first mesa about one mile north of Presidio, Texas, covered with numerous clumps of the "blood-of-the-dragen" *Jatropha spathulata*. Ocotillo in upper right corner.

tains a number of species of plants and animals found nowhere else in the United States east of south central Arizona.

On the rocky slopes of the lower plateau-like hills in the Chinatis tall grasses, such as *Stipa leucotricha, Andropogon, Aristida, Muhlenbergia* spp. and *Bouteloua* spp., abound. The dwarf round-flowered catclaw, *Acacia Roemeriana* with pink tassel-like flowers, is the dominant shrub with the grasses at elevations up to 5000 feet, and on the slopes *Nolina texana,* sotol and *Acacia Roemeriana* occur. In places, communities of sotol and very tall grasses flourish on the mountain sides at 5000 to 5500 feet. On the broad plateaus at 5500 feet or more gramma grass with narrow-leaved yucca are dominant.

In the shade of cliffs in the higher valleys at 5000 to 5500 feet a great variety of flowers and shrubs are found blooming in late summer visited by the large black and yellow bumblebees, *Bremus sonorus.* This greater wealth of flowers is due to the greater moisture supply, lower temperatures and decreased aridity, and is indicative of the Mexican Upper Sonoran flora. Limits cannot be set, however, for the higher the altitude above 5000 feet the more strongly the floral aspects become typical Upper Sonoran (grasslands). On the steep north slopes of Blue Mountain, second highest peak in the Chinatis and 6700 feet in elevation and ranging from the flat plateau top down to about 5500 feet, an oak zone of *Quercus virginiana* exists, as in the Davis Range, with some hackberry, *Celtis pallida,* and Mexican walnut at the lower reaches. This is typical Upper Sonoran and in this oak zone were found several orthopterans not previously taken in the Chinatis, the same species as inhabit the oak zone of the Davis Mountains. The narrow table-topped peak of Blue Mountain (6700 feet) was dominated by one-seeded juniper and the grasshopper fauna here was typical of similar elevations in the Davis Mountains 100 miles to the north.

C. TRANSITION ZONE

The flora of the Transition Zone is found only on the highest peaks of the Big Bend Region. It is probably present on the north slopes of Chinati Peak but apparently no studies, by anyone, have been made on that inaccessible section of the Chinatis.

On the northern slopes of Mt. Livermore of the Davis Range, and highest peak in the Big Bend, the Transition Zone is represented by western yellow pine, *Pinus ponderosa,* and *Pinus flexilis;* the oaks *Quercus Gambelii* and *Q. hypoleucoides;* and quaking aspen, *Populus tremuloides,* which are the principal trees of this zone.

The commonest shrubs are mountain snowberry, *Symphoricarpos oreophilus,* bush rock spirea, *Holodiscus Wrightii,* Arizona sage, *Salvia arizonica,* wild geranium, *Geranium atropurpureum,* sagebrush, *Artemisia dracunculoides* and *A. mexicana,* golden aster, *Chrysopsis hispida* and *Eupatorium Fendleri.* Cacti are represented by *Opuntia strigil* and *O. chlorantha.*

Grasses are many including *Koeleria cristata, Bromus ciliatus* and *B. carinatus, Muhlenbergia montanus, Agropyron arizonicum, Stipa tenuissima,* and the gramma grasses, *Bouteloua gracilis* and *B. hirsuta.*

The higher peaks of the Chisos represent the Transition Zone, and these are interesting in that different peaks have different members of this flora. Mt. Emory, the highest peak, has the only aspens found in the range and Arizona cypress, *Cupressus arizonica,* and Douglas fir, *Pseudotsuga taxifolia,* are found at Boot Springs near its northern base. A few Douglas fir also grow on the higher slopes of Casa Grande. Western yellow pine grows only in Pine Canyon, a large canyon between Lost Mines and Crown peaks. Pulliam Bluff has the only growth of Bray's chestnut oak, *Quercus Muhlenbergii Brayi.* The bigtoothed maple, *Acer grandidentatum,* and the Chisos red oak, *Quercus Gravesii,* are more generally distributed on the various high peaks of the Chisos. The above mentioned trees typify the Transition Zone in the Chisos Mountains.

Fauna of the Big Bend Region

THE ORIGIN AND ADAPTATIONS OF DESERT ORTHOPTERA

Of the various orders of insects, the Orthoptera are more graminiphagous than any other group. Especially in northern latitudes orthopteran life is solely dependent upon the grasses for sustenance. Food here is usually plentiful.

On the desert, however, where grasses are scarce we find that many species have assumed an arboreal or thamnophilous (bush-loving) habit and become restricted to a particular host plant. This is a forced modification due to the nature of the environment. Search of food probably first induced grasshoppers to become shrub feeders, and as they grew in harmony with their new surroundings the different species eventually completed their life cycle on the plants themselves. This is true of many species of the Lower Sonoran Orthoptera which are dominantly of Mexican origin.

In addition to the sparsity of the flora of the desert, the bareness of the desert pavement and the intensity of the sunlight produce temperatures that would be fatal to most organisms. Hence the desert Orthoptera, especially the grasshoppers or the Acrididae, were forced to the scant shade of the plants themselves or what was preferable, to evade the high temperatures of the soil and the air contiguous to it, by climbing or jumping or flying into the bushes. In fact many species of winged grasshoppers such as *Trimerotropis* spp., *Tythotyle maculata* and *Derotmema delicatula,* etc., remain on the soil of the desert until the maximum temperatures force them to seek the protection of the foliage. Usually this is not a case of hiding in the foliage as much as resting on the leaf exposed to the rays of the sun.

In the Imperial Valley many winged acridids that remain on the soil when temperatures are suitable, cannot be forced to fly from the bushes to the ground during the intense heat of midday when shade temperature run 120 degrees Fahrenheit and soil temperatures reach 150 degrees, but fly directly from bush to bush when disturbed.

The extensive sand areas of the Imperial Valley representing a tropical or xerothermic Colorado Desert have developed certain grasshoppers adapted to living on its burning sands. These acridids include the rare and unique *Spani-*

acris (*Ramona*) *deserticola, Coniana snowi* and *Xeracris minimus. Spaniacris* has long slender legs to raise its body off the sands and the long caudal tibiae are inbent apically to give the creature purchasing power when it takes to flight from the sand. *Coniana* is squat and short-legged yet is able to exist here where the only plant is the low cespitose *Coldenia Palmeri* which would not raise their bodies half an inch off of the sand.

Other species such as *Cibolacris parviceps, Tytthotyle maculata, Lactista oslari, Trimerotropis pallidipennis, Trepidulus rosaceus* have a wider distribution upon the deserts of southeastern California and Arizona where they inhabit volcanic desert pavement and gravelly arroyos, while in similar habitats in southwestern Texas we find such saxicolous species as *Trimerotropis texana, Heliastus benjamini, Phrynotettix robustus* and *tschivavensis* and *Anconia hebardi.*

Thamnophilous species such as *Aeoloplus elegans* and *Camplyacantha olivacea vivax* seek shelter when danger threatens, by jumping down into the bushes they are on, where the brittle joint cactus *Opuntia leptocaulis* often affords the desired protection.

Others such as *Ligurotettix coquilletti* of the Sonoran Desert play hide and seek on the bare stems of creosote and *Franseria dumosa* and are almost impossible to capture without the use of forceps. So also does *Goniatron planum* of the Chihuahuan Desert on its host plant *Flourensis cernua.* Likewise the wingless *Clematodes larreae* on its host plant, the creosote bush, escapes detection by its deceptive habits.

Thus the desert acridids due to their more precarious and diversified habits, show more interesting adaptations to their environments than do the grassland grasshoppers.

These adaptations are not only physical but morphological as well, and many strange modifications occur, the most striking examples being the fat ponderous "toadhoppers" of the genus *Phrynotettix* which have brachypterous or rudimentary wing pads and broad squattish bodies. In fact many acridids throughout the desert regions of the world have developed into this broad and squat form. Others such as *Spaniacris* have developed long slender legs to raise their bodies off the sand. Still others have become greatly slenderized to resemble the stems of desert grass. Thus *Prorocorypha snowi,* the "Matchstick Grasshopper," is exceedingly long and slender so that when it rests on a grass stem with its long ensiform antennae aligned forward, it takes a sharp eye to spot it. Almost as remarkable is the very rare *Achurum sumichrasti* of southwestern Texas and species of *Eremiacris* such as *virgata, perpallida* and *acris* exhibit similar form and habit.

Protective coloration is exhibited in most orthoptera, with striking exceptions in the nigger grasshopper, *Boopedon nubilum,* the rainbow grasshopper, *Dactylotum variegatum,* and the large and showy black and yellow horse lubber, *Taeniopoda eques,* although in the latter case these colors may be warning.

Striking examples in the opposite extremes are exemplified in certain saxic-

oleus and thamnophilous species. The very rare *Anconia hebardi* and the commoner *Cibolacris parviceps, Heliastus benjamini* and *Trimerotropis texana* blend perfectly with the rocks and gravel of the arroyo beds that constitute their home. *Coniana snowi* is finely speckled like the sands of Imperial Valley and *Spaniacris deserticola, Tytthotyle maculata, Lactista oslari, Arphia aberrans* and many other species show as remarkable a protective coloration.

Of thamnophilous species, those orthopterans dwelling in creosote bush, the dominant plant of the desert, exhibit a strange coloration. *Bootettix argentatus* and *punctatus* and the katydids *Anoplodusa arizonensis, Insara covilleae, Rehnia cerberus* and *victoriae* are all foliage green with nacreous markings, the latter markings probably representing the sun glistening on the shining sticky leaves of the creosote. Others such as *Clematodes, Goniatron* and *Ligurotettix* are grayish colored to resemble the stems of desert plants such as creosote, *Flourensia* and *Franseria* which they inhabit respectively.

Many desert species such as *Netrosoma nigropleura* and *Zapata brevipennis* and species of *Philocleon* and *Phaedrotettix* escape from their enemies by their remarkable jumping powers. Others like *Phaulotettix eurycercus* feign death and drop into the centers of spiny sotol bushes, with which they are associated, and thus are safe. *Oedomerus corallipes* crawls down under the rocks on mountain slopes to elude its enemies.

Host plant relationships also have been especially developed. Despite the sticky and pungent leaves of the creosote, this plant which appears to be decidedly unpalpable to many species has yet developed a considerable array of orthopterans restricted to it. In addition to *Bootettix, Insara, Anoplodusa* and *Rehnia* mentioned above, species of *Dichopetala, Eremopedes* and the stick insect *Diapheromera* are restricted to it. Other desert species are found on *Flourensia, Franseria, Gutierrezia, Baccharis* and *Artemesia.*

This in brief outlines some of the interesting adaptations of desert orthopterans to their habitats.

INSECT DISTRIBUTION AND ABUNDANCE ZONES: ENDOGENES AND ECTOGENES

Every species has its range of *optimum abundance* where the combined factors of climate (temperature, rainfall and humidity), food and edaphic features are most favorable to its existence. Rare species only exist because those specimens taken are usually far from the optimum zone of their distribution, and are rare because conditions are so drastic or unfavorable, or in other words the environmental resistance or pressure is so great that few survive. In the optimum zone the species encounters the least environmental resistance. Outside this zone, if it be defined by study, one will find a zone or area of *lesser abundance* where the species will always be found but in small numbers. This zone grades off imperceptibly on its outer periphery to an area of *rarer occurrence* where the factors of climate and food are so adverse that only a few individuals of a species survive to propagate the race. In the area of rarer

occurrence should climatic conditions become more drastic, i.e. swing further away from the optimum requirements of the species, it will disappear; if cyclic climatic fluctuations move towards more favorable conditions or towards the optimum, the species will increase in numbers but never to the point of being common unless the change is great.

This last zone might be considered as a zone of tension for every species of animal or plant, by its life activities, is striving to increase or extend the boundaries of its distribution. This is an inherent characteristic of the species; a time-space attribute for the propagation of the race. When for a series of years conditions do become more favorable or in other words the factors keeping the species in check are lowered in the environment, the species extends itself over a greater area. The reverse occurs when the conditions in the habitat become unfavorable and the resistance is high; the species is decimated in numbers.

But in the center of its distribution, the optimum of the species, where it has evolved through the ages and becomes attuned to the existing conditions, the species is always present in greatest numbers. The writer has formed the term *endogene* to indicate a species found in its optimum zone, or in other words that region in which it is particularly indigenous. Similarly by the term *ectogene* the writer refers to a species outside its optimum zone, where it is more or less rare and can be considered as living in an environment that is none too mild in character, and in which it finds a difficult livelihood.

ORTHOPTERAN ZOOGEOGRAPHY

With such a diversity and abundance of orthopteran life to contend with as is represented in the Big Region of Trans-Pecos Texas, it is imperative that a thorough knowledge of the region be had. For this reason we have already dealt with the flora of this region, which was divided floristically, by the nature of the physiography of the region and its associated plant formations, and faunistically by the character of the orthopteran fauna associated with the flora into a series of two or possibly three faunal zones and each with several subzones or faunae.

Despite this statement the writer realizes how difficult it is to interpret faunal zones and faunae, especially when the region being dealt with lies in the midst of a vast uncharted area.

This study has shown, for instance, that due to the geographic location of the area, its physiographic diversity, its constantly changing floristic features as well as a considerable range in altitude from the Rio Grande Valley (2600 ft.) to the highest peaks (8300 ft.), the area has proved to be the meeting place of many faunae.

Our problem is to break up this mass of species into its component elements, and in doing this it will be essential to study the known distribution of each orthopteran species and to determine from the records and the writer's own observations not only here but throughout the various deserts of North America, whether the species is an endogene or ectogene in the floristic habitat in which it is found.

The known distribution of each orthopteran species has been plotted on prepared maps of North America and from this study the various species have been seriated into groups or faunae.

It does not necessarily follow that two species sharing the same habitat belong to the same group. One may be an endogene, the other an ectogene in this habitat, and consequently cannot be classed together. Plotting their respective distributions in this case will show that their geographic ranges do not coincide.

Hence if we make a transect of the region from the Rio Grande at Presidio to the highest peak, Mt. Livermore to the Davis Range, 100 miles away to the north, and make this transect an altitudinal one; by adding symbols to represent the dominant flora of each area, we can roughly define the floral zones of the Big Bend. Then by listing the endogenes of each floral zone, a faunistic-floristic transect of the region under consideration is obtained (Fig. 23). An analysis of this transect and all the component elements making up the whole, constitutes the scope of this paper.

It must be remembered that each fauna overlaps on its margins with adjacent faunae forming an area of intermingling commonly called an ecotone. The members of a fauna are usually endogenes but the members of an ecotone are usually ectogenes, as change in altitude, and climate, the presence of new plants replacing the old, change the features of the habitat and bring environmental pressure to bear on certain species thus reducing their numbers.

FAUNAL ZONES AND THEIR SUBDIVISIONS OR FAUNAE

A. The Lower Sonoran Faunal Zone is represented by the following subdivisions which are not all natural divisions:

   a. Rio Grande Valley possessing a variable and unnatural fauna due to changes wrought by agriculture.

   b. Desert Mesa comprising the typical fauna of vast stretches of the desert and this fauna is chiefly indigenous to the Chihuahuan Desert, and is called the Chihuahuan Lower Sonoran fauna.

   c. Mexican Lower Sonoran fauna is identified by a floral and faunal zone ranging approximately from 4200 to 4800 feet, that can also be called the lower desert mountain zone and is chiefly characterized by the plants, sotol, lechuguilla and ocotillo, and by limestone.

B. The Upper Sonoran Faunal Zone is divisible into four main components or faunae:

   a. Southern Short Grasslands fauna developed on the more arid short grasslands of the Western Plains. This fauna extends from southeastern Alberta, eastern Montana and North Dakota, southwest of the Missouri, south to the Panhandle and central Texas and east of the Rockies to southwestern South Dakota, western Nebraska and Kansas and western Oklahoma. In the Southwest this fauna follows the grasslands south through New Mexico to southeastern Arizona and southeastward to the Big Bend Region.

   b. Southwestern Grasslands fauna represents a fauna of the southwest ranging from southeastern Arizona to Trans-Pecos Teras, south to Chihuahua and Durango and northeast throughout New Mexico to eastern Colorado and southwestern Kansas.

   c. Mexican Upper Sonoran fauna is widespread over the Mexican Plateau finding its northern limits of distribution in southcentral Arizona mainly from the Babo-

quivari, Tumacacori and Huachuca Mountains, with elements in the Ajos, Santa Catalinas and Chiricahuas. In Trans-Pecos Texas, the fauna reappears only in the Chinatis and perhaps in the Chisos. Recent botanical explorations by Johnson and Mueller (1940-41) in northern Coahuila and Chihuahua indicate this isolated Texas unit is most probably connected with the main fauna in the Sierra Madres Occidentale *via* the mountainous masses of central Coahuila and southern Chihuahua. It does not appear to be connected with the Sierra Madres Orientale.

d. Chihuahuan Upper Sonoran fauna represents a small fauna of the Upper Sonoran Zone which is restricted to Trans-Pecos Texas and northeastern Mexico.

C. The Transition Faunal Zone appears to have two components.

a. Northern Short Grasslands fauna composed of a series of species inhabiting the northern plains of the southern portions of the Canadian prairie provinces and in the United States occupying that area extending east of the Rockies to the western edge of Minnesota, most of South Dakota and Nebraska, western half of Kansas, and ranging throughout northern New Mexico to the grasslands of the Mogollon Plateau of Arizona and the higher grasslands of the Big Bend Region.

b. Southwestern Mountain Transition fauna is composed of a group of species indigenous to the Oak and juniper zones of the southwest ranging from the higher elevations of the Chisos, Davis and Chinati Mountains to the eastern half of Arizona and north to southern Colorado.

FAUNISTIC ECOLOGY OF THE BIG BEND REGION

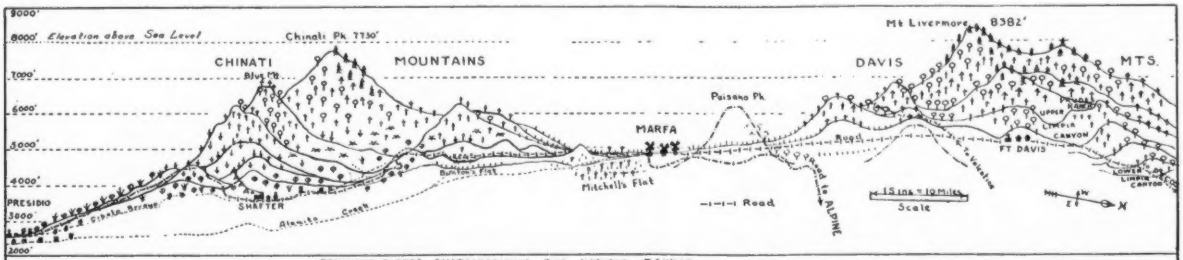
A. LOWER SONORAN FAUNAL ZONE.

a. *Rio Grande Valley.*—This fauna shows great irregularity due no doubt to the agricultural practices carried on in the Valley. These have produced verdant fields of cotton and alfalfa and other crops and with irrigation mitigating the effects of the climate, has thus given variety to its fauna.

Thus the cotton fields are conducive to the development of many species such as the bird-winged locust, *Schistocerca vaga, S. americana, Melanoplus bowditchii propinguus,* the tree cricket, *Oecanthus californicus,* and the katydids *Scudderia furcata furcifera* and *Insara elegans.*

On patches of sand in the cotton fields and elsewhere *Trimerotropis citrina* is common with an occasional *Spharagemon collare cristatum* found. The latter species is not to be confused with *Spharagemon bolli inornatum* which is found under oaks in the mountains.

Along grass covered irrigation ditches where Bermuda grass is dominant, *Platylactista aztecus* and *Encoptolophus subgracilis* occur and in more damp locations *Syrbula fuscovittata* and *Orphulella pelidna deserta* are sometimes found, while *Conocephalus strictus* was taken rarely in the tall grass bordering a small slough. *Derotmema haydenii mesembrinum* was found on certain mesquite-covered adobe flats and *Trimerotropis p. pallidipennis* was abundant everywhere. The rare *Anconia hebardi* was found on bare adobe flats and adjacent arroyo beds in the valley upriver from Presidio near Indio. Other species were taken such as the mantids *Stagmomantis californicus* and *Litaneutria minor* and the cockroaches *Arenivaga erratica* and *Eremoblatta subdiaphana,* the two latter mainly at lights. A unique specimen of *Dissosteira*



AUSTRAL FAUNAL REGION

1. LOWER SONORAN ZONE

Lower Sonoran Fauna 1a&c		Mexican L. 1c, Sonoran Fauna	Chihuahuan L. 1c Sonoran Fauna
P. desertae	Oecanthus sp.	E subdiaphana	D corolla
S. californica	H borealis	A piperatus	D torquata
S. limbata	M lineatus	Z. brevipennis	D v eucnemis
P. m mexicanus	M. rhombifolium	C. larreae	B argentatus
E. subgracilis	M. aridus	T. equus	P maculipennis
S. c. cristatum	N. c mormonius	C c fortior	G planum
P. asterus	A. erratica		D. h mesembrinus
M. terricolor	Lower & Upper		T texana
T. strenua	S. Fauna	Austroriparian & Humid L. Sonoran	A hebardi
T. latifasciata	P americana	T citrina	P robustus
C p. diridus	B germanica	S americana	P eurycercus
S. v vaga	P stramineus	R. huasteca	C. e. vivax
N herbaceus?	P a. asteca	M. lineatus	E elegans
M. f elongatus	M texana	M denticrus	D. brevirhastata
M b propinquus	P t pusilla		P nigrovittata
I. c elegans	A aberrans		N nigropluura
N. triops	T p pallidipennis	Eremobotis n sp	P eurycercus
C. fuliginosus	M d. nigricans	C. variegatus	R. cerberus
N. c neomexicanus	S f furcifera	E. coviliege	P. tinkhami
O californicus	S. subpellectilium		E. scudderi

2. UPPER SONORAN ZONE

Mexican U. 2a. Sonoran Fauna	Chihuahuan U. Sonoran Fauna	SW. Grasslands Fauna 2 b.c.	S. Short Grass lands Fauna 2c.	Upper 2a&b. Sonoran Fauna
A grata	P. d palmeri	Y solitaria	L minor	P coloradus
A sumichrasti	A. m crypsidomus	O scudderi	C o occipitalis	D femoratus
A mysteca	M eumera	A variegatus	C c crenulata	M neomexicanus
R v viatoria	P excelsus	S fuscovittata	B nubilum	L wheeleri
H benjamini	C rehni	O imperfecta	D femoratum	S shoshone
A insolita	C. polingi	E variabilis	D longipennis	D variegatum
	A. arachnopyga	H rufa	B. magna	C. stricticus
	A. semialata	A p crassa	M lahinus	M d. nigricans
	A. g cerciata	X c pantherinus	M o occidentalis	H rugosus
	T tschivavensis	T formosus	O p deserta	M f elongatus
Tamaulipan Semi-Desert Bushland	D. oreoeca	T h fusciprons	C pallidus	
R. victoriae	C carlsbadensis	R capito		Upper Sonoran Humid
A tonkawa	S. chinatiensis n sp	M p corrugatum		S admirabilis?
P nigrovittata		T laticincta		M glauerpes
		T melanoptera		P bruneri
		T magnifica		C c comprehendens
		E virgata	Unknown	Nr crepitans
	M arizonae	H V viridis	C conicaudus	O c concinnum
	M regalis	M desultorius		
		M thomasi		

3. TRANSITION ZONE

N. Short 2c.3a. Grasslands F.	Southwestern Mtn. Fauna 3b.
A coloradus	L cyaneus
P 4-maculatus	S b inornatum
P d deorum	T aspera
P d delicatula	T cyaneipennis
A elliotti	C utahensis
D carolina	M. aridus
T pistrinaria	C. Isletae
H trifasciata	P tschivavensis
S lineata	
M gladstoni	
M f-r femur-rub?	
M m mexicanus?	
P nebrascensis	
C f fasciatus	
C pellidus	
L + U Sonoran & Transitional	
G assimilis	

Fig. 23.—A faunistic-floristic transect of Presidio and Jeff Davis counties.

carolina was taken in the Valley but to venture a guess how this transitional species came to be in the Valley would be hazardous.

b. *Desert Mesa.*—The Chihuahuan Desert fauna of the desert mesa has its most interesting Orthoptera in its thamnophilous members mainly dwelling in the creosote bush. The creosote grasshopper, *Bootettix argentatus,* is found everywhere on the creosote bush which characterizes the Chihuahuan Desert. Other inhabitants are the large stick-insect, *Diapheromera covilleae,* the tiny Mogoplistine cricket, *Cycloptilum comprehendens fortior,* and the newly described katydid, *Eremopedes covilleae,* discovered by the writer. Other katydids such as *Eremopedes scudderi, Rehnia cerberus* and the pretty *Dichopetala oreoeca* feed on creosote as well as other plants. A much larger decticid fauna is found on the creosote bush on the Sonoran Desert.

Goniatron planum and *Camplyacantha olivacea vivax* are found on *Flourensia,* the blackbrush, the latter common only in Brewster County. The beautiful spiny-legged *Rehnia cerberus* is found chiefly in mesquite. *Aeoloplus elegans* was found on Four-wing Saltbush, *Atriplex canescens,* its host plant.

Trimerotropis pallidipennis is ubiquitous everywhere on the mesa and the arroyo grasshopper, *Cibolacris parviceps,* prefers the arroyo beds crossing the mesa.

Of truly saxicolous species, those restricted to gravel and sand, the following are noteworthy: *Anconia hebardi, Trimerotropic texana* and *Cibolacris parviceps.* Rarely is the Texas toadhopper, *Phrynotettix robustus,* taken on gravelly ridges on the desert mesa.

Mestobregma terricolor is a rare terricolous species limited to certain adobe hill regions north of Presidio.

Graminiphilous species are rare, if not absent, for practically no grass is to be found on the desert mesa.

c. *The Mexican Lower Sonoran Fauna* is represented by an altitudinal zone ranging from approximately 4200 to 4800 feet in the Chinatis. It is one of the richest and most interesting of the faunae of the entire region and the Southwest. Possibly few mountainous regions of the Southwest would eclipse in interest, variety and abundance, this fauna found in the Chinati Mountains.

This fauna is predominantly Mexican in origin for being situated in the Lower Sonoran Zone, the Chinatis represent the northernmost extension of many Mexican species, while the Davis Mountains show strongest affinities with a more northern fauna. The Chisos range not only contains many of the Chinati species but by their proximity to the Pecos Valley and the Tamaulipan Semi-desert Bushland coming up the coast of the Gulf of Mexico, a strong influx of species from the east is also indicated.

The most characteristic endogenes of this Mexican fauna are the following species: *Zapata brevipennis, Pedioscirtetes maculipennis, Acantherus piperatus, Trimeotropis pistrinaria* (optimum phase), *Clematodes larreae, Netrosoma nigropleura, Phaulotettix eurycercus, Philocleon nigrovittata,* the katydid, *Pediodectes tinkhami,* discovered in 1929, and the small cricket *Haplosphyrum boreale.*

The short gramma grass cover on gravelly spots, which are sometimes found, usually support such species as *Phrynotettix robustus, Dactylotum variegatum* and *P. maculipennis.*

On the hillsides with sparse coverage of *Nolina texana* and *Acacia Roemeriana,* the rare *Zapata brevipennis* occurs and the even rarer *Netrosoma nigropleura.* The females of this latter genus are at least twice the size of the tiny males and have the curious habit of dropping their hind legs when held. The minute males have unusual saltatorial propensities.

The rare *Phaulotettix eurycercus* is sometimes found in the clumps of sotol. *Phaedrotettix dumicola palmeri* and *Agroecotettix modestus* are sometimes taken but they are endogenes of the Mexican Upper Sonoran fauna. On certain hilltops where the soil seems more damp probably due to the presence of the Resurrection plant and its terracing effect, *Trimerotropis pistrinaria* is found. They were found at no other locality than at (1) a valley about two and one half miles south of Shafter. These specimens of optimum size are about twice the size of northern specimens from Montana and Alberta and may represent a southern race. Here also is found *P. maculipennis* while *Mermiria texana* occurs abundantly and ranging upwards through the Mexican Upper Sonoran Zone. *Schistocerca vaga* is more often seen than taken because of its swift sustained flight. Rarer species that are occasionally taken mainly in clumps of desert vegetation include: *Acantherus piperatus, Clematodes larreae* and the infrequent *Pediodectes tinkhami. Rehnia cerberus* is found in mesquite, *Dichopetala oreoeca* on certain vegetation and *Melanoplus aridus* on *Dahlia Parryi.*

Sometimes interesting ectogenes are discovered. On one occasion I took a specimen of *Aulocara elliotti* on a desert hilltop at (1) and sixty miles south of the grasslands on which it is occasionally found. It was rescued from the beak of a large asilid fly. Such records prove the saying that each species is forever striving to extend its range or "striving for its place in the sun." Indeed such species as *T. pistrinaria, P. maculipennis, M. texana, A. piperatus* and *M. aridus* are strange associates. A specimen of *Brachystola magna* also taken here was an interesting ectogene.

Of saxicolous species *Cibolacris parviceps* and *T. texana* (rarely) were found in the gravel beds of Cibolo Arroyo, near Shafter. An interesting ectogene here was *Heliatus benjamini,* a single specimen was the only one found south of the Davis Mountains.

Semi-saxicolous species include the toadhopper *P. robustus, T. p. pallidipennis* and *Platylactista aztecus,* although the latter favors the presence of a little grass.

At higher elevations in tall grass *Syrbula fuscovittata, Opeia imperfecta, Eritettis variabilis* and *Psoloessa texana pusilla* were taken.

In the mountain valleys at about 4500 feet elevation, the beautiful and large *Taeniopoda eques,* shining black in color with bright yellow trimmings and rose-red wings, is found on its host plant, *Trixis californicus,* a small yellow-flowered composite. At this elevation many members of the Upper Sonoran Faunal Zone begin to appear.

B. UPPER SONORAN FAUNAL ZONE

a. *The Mexican Upper Sonoran Fauna* is restricted to a narrow zone of tall grass of steep north slopes at about 5500 feet elevation and is quite limited in nature. East of Arizona, this fauna is known at present only from the Chinati Mountains and efforts to find it in the Chisos failed in October, 1946. Only four members of this fauna are at present known in Texas, namely, *Achurum sumichrasti, Amblytropidea mysteca, Rhammatocerus viatoria viatoria* and *Amblycorypha insolita. Arenivaga grata* probably belongs to this fauna too as Hebard (1943) has just recorded the first Texas specimens from the scrub oak zone in the Chisos. Further search in the Chisos may reveal other members of this fauna present.

The Upper Sonoran Zone, however, attains its greatest development on the grasslands which represent two or possibly three faunae, namely, the Southwestern Grasslands fauna and the Southern Short Grasslands fauna and possibly a third designated here as the Chihuahuan Upper Sonoran fauna.

b. *Southwestern Grasslands Fauna.*—Typical members of this fauna include the following: *Arphia crassa, Xanthippus corallipes pantherinus, Leprus wheeleri* and *L. cyaneus, Trimerotropis melanoptera, T. magnifica, Heliaula rufa, Melanoplus lakinus, M. desultorius, M. regalis, M. arizonae,* and *M. thomasi. Acrolophitus variegatus* is found on stony soil with poor grass cover. *Derotmema h. mesembrinum* occurs on grass covered patches of adobe soil, and in tall grass on hillsides *Mestobregma plattei corrugata* is found. The katydid, *Scudderia furcata furcifera,* is a common member of this fauna. Other species include *Eritettix variabilis,* atypical *Psoloessa texana pusilla,* the handsome *Dissosteira longipennis* and the remarkable *Tropidolophus formosus* with high, serrate-edged pronotal crest, green coloration and orange wings, *Rehnita capito,* and *Hesperotettix v. viridis.*

c. *Southern Short Grasslands Fauna* includes: *Cordillacris o. occipitalis, C. crenulata, Boopedon nubilum, Drepanopterna femoratum, Trimerotropis leticincta, Melanoplus occidentalis, M. differentialis nigricans,* the mantid, *Litaneutria minor,* the lubber, *Brachystola magna,* and the bird-wing locust, *Schistocerca lineata.*

d. *Chihuahuan Upper Sonoran Fauna.*—A few species appear to be restricted to the Upper Sonoran Region of Trans-Pecos Texas and are here designated as Chihuahuan Upper Sonoran. No representatives of this fauna occur in Arizona and hence this fauna is distinct from the Mexican Upper Sonoran fauna. *Melanoplus eumera* and the stick insect *Diapheromera torquata* appear to belong to this fauna. *Ceuthophilus rehni* may also represent this fauna, as well as *C. carlsbadensis,* and *C. polingi.*

Two species *Heliastus benjamini* and *Phrynotettix tschivavensis,* a toad-hopper, do not appear to fall readily in any of the faunae already discussed, although both appear to be endogenes of the Upper Sonoran Region.

C. TRANSITION FAUNAL ZONE (approximately above 6500 feet on northern exposures and 7000 feet on southern exposures)

a. *Northern Short Grasslands Fauna.*—The distribution of members of this fauna are more extensive than those of the Southern Short Grasslands fauna whose composite range extends no further north than the Milk River Valley of extreme southeastern Alberta. On the other hand the composite range of members of the Northern Short Grasslands fauna extends well into the southern portions of the three Canadian prairie provinces of Alberta, Saskatchewan and Manitoba. Members of this fauna consequently appear to have a greater flexibility in life requirements than members of the Southern Short Grasslands fauna and the Southwestern Grasslands fauna for such species as *Hadrotettix trifasciatus* and *Aulocara elliotti* are found in the same habitat as the members of the two last mentioned faunae. In fact one specimen of *A. elliotti* was taken in typical desert habitat of the Lower Sonoran.

Members of this fauna are: *Hadrotettix trifasciatus, Aulocara elliotti, Melanoplus gladstoni, Ageneotettix deorum, Photaliotes nebrascensis, Psoloessa delicatula* and *Philbostroma quadrimaculata.* These are mainly found in grasslands in the Davis Range.

b. *Southwestern Mountain Transition Fauna.*—A fauna peculiar to itself and developed only in the Transition Zone of the mountains of the southwest is here designated as the Southwestern Mountain Transition fauna.

It is represented typically by such species as *Trimerotropis cyaneipennis, Spharagemon bolli inornatum, Trachyrhachis aspera, Ceuthophilus utahensis C. isletae* and *Mermiria neomexicana.* Other species found associated with these are: *Pediodectes bruneri, Schistocerca lineata, Conocephalus strictus* and *Hippiscus rugosus,* an oak-sylvan species in the Davis Range but inhabiting tall grasses in the Chinatis. These four latter species are not true members of this fauna.

The stick insect, *Diapheromera femorata,* probably belongs to this fauna although widespread over the eastern United States at present. Hebard (1943, p. 305) believes that this is an ancient species of this region having spread to its present range in more recent times.

Notes on Collecting Localities

The major portion of the collecting was confined to the Chinati Mountains within a six mile radius of the mining town of Shafter during the years 1928 to 1931. Collections were also made in the Marfa region and the Davis Mountains during this period and also in 1940. Collections were made on the northern slopes of the Chisos in July, 1930, and other additional collections have been in the Davis, Chinati, Dead Horse and Chisos Mountains in October, 1946, when the writer resumed desert studies after return to civilian life.

Reference to the first six numbers as localities in the Chinati Mountains will be found in the text. The remaining numbers are for listing only.

1. A valley 2½ miles south of Shafter on the Shafter-Presidio road. Elevation about 4200 to 4500 feet. Typically Lower Sonoran. Collections were made here on: Sept. 30, Oct. 28, Nov. 8, 1928; July 8, Aug. 4, Sept. 29, Oct. 12, Oct. 19, 1929; March 28, June 15, June 22, June 29, 1930, night of Sept. 22 and Sept. 23, 1931, Oct. 16-19, 1946.

2. Shafter mountain about 1½ miles north of Shafter on the old Shafter-Marfa road. Elevation 5100 to 5500 feet. Sept. 30, 1928.

3. A valley about 5 miles WNW, of Shafter at about 5000 feet and intervening territory collected on: Sept. 9, Sept. 16, Sept. 23, 1929; May 4, June 6, and July 8, 1930, Oct. 19, 1946.

4. The steep north declivity of a plateau cut by a narrow ravine at about 5500 feet elevation 5 miles WNW, of Shafter. Mexican Upper Sonoran fauna discovered here and thoroughly collected on May 4, June 6, and July 8, 1930, Oct. 19, 1946.

5. Elephant Rock, 28 miles north of Presidio on Presidio-Marfa road, collected on Sept. 3, 1928; Sept. 29, 1929 and June 22, 1930.

6. Bunton Flat just north of Elephant Rock. Brief collecting here in Tobosa grass on June 29, 1930, Oct. 20, 1946.

7. Blue Mountain trip from Bunton's Ranch House on Sept. 27, 1931. Intensive collecting during entire day from Cibolo Arroyo at 4200 feet to top of Blue Mountain 5 miles away at 6700 feet altitude.

8. Dawson's ranch and vicinity, 8 miles southeast of Shafter on July 8, 1929.

9. A grassy gulch collected on June 22, 1930 about 36 miles north of Presidio on Marfa road.

10. Bofecillo Mountains, 20 miles east of Presidio on July 4, 1929.

11. Grasslands at 5500 feet elevation at head of Pinto Canyon, in northwestern portions of Chinatis on June 8, 1930.

12. Marfa, Texas, collections on 4-5 Oct. 1929 and June 22, 1930.

13. About 8 miles south of Marfa, collected June 22 and 29, 1930.

14. About 6 miles east of Marfa on poor stony soil with sparse grass cover, collected on June 22, 1930 and Aug. 13, 1940. *Acrolophitus variegatus* taken here in 1930.

15. About 6-10 miles west of Marfa, collected Aug. 13, 1940 and Oct. 30, 1946.

16. Paisano Pass region, elev. 5200 feet or more, half way between Marfa and Alpine. Collected Oct. 8, 1928, June 23 and 29, 1929 and June 22 and 29, 1930; also Oct. 29, 1946.

17. Near south base of Davis Mts., northwest of Marfa. Collections made with Mr. F. F. Bibby on Oct. 22, 1928. Also Sept. 28, 1931.

18. Lower Limpia Canyon, McCutcheon's Ranch, Oct. 5, 1929, Oct. 12, 1946.

19. Upper Limpia Canyon near Prude's Ranch, Oct. 6, 1929, Oct. 13, 1946.

20. Pine covered mountain slopes about 3 miles NNE, of Mt. Livermore on the Perkin's ranch near present McDonald Observatory. Oct. 6, 1929. Elevation about 6500 feet or more.

21. An intensive day's collecting by the writer and his brother on the south slopes of Mt. Livermore on the Cox's Ranch from elevations of 6000 to 8000 feet, Sept. 29, 1931.

22. North side of Davis Range, 8 miles east of Kent, Sept. 14, 1940.

23. North slopes of Davis Range, 6 miles SW, of Toyahvale, collected on Sept. 13-14, 1940.

24. West base of Mt. Emory, Chisos Mts., near Wilson's Ranch, July 17, 1930.

25. Wadi Burnham's Ranch House, now Government Springs, north side of Lost Mines Peak, Chisos Mts., July 16, 18, 1930, Oct. 28, 1946.

26. Desert 20 miles north of Chisos on Marathon Road, July 18, 1930. Type locality of *Eremopedes covilleae* Hebard. Also Oct. 23, 1946.

27. 17 miles east of Marathon, collected on Aug. 14, 1940.

28. 5 miles east of Sanderson, collected on Aug. 14, 1940.

29. 8 miles east of Van Horn, collected Oct. 23, 1943.

30. Mouth of Lower Limpia Canyon, 20 miles SW, of Balmorrhea, 12 Oct. 1946.

31. 10 miles north of Marfa in community of *Flourensia cernua*, collected Oct. 13, 1946.

32. 1 mile north of Bunton Flat in *Flourensia* community, collected Oct. 21, 1946.

33. 3 miles east of Alpine on small rocky knoll covered with *Acacia greggii*, collected 22 and 29 Oct. 1946.

34. 20 miles south of Marathon in tall grass around a roadside spring, Oct. 22, 1946.

35. Persimmon Gap region, 44 miles south of Marathon in the Santiago Mts., collected Oct. 22, 23, 1946.

36. Cooper's Store, 45 miles south of Marathon on north edge of Big Bend Park, collected Oct. 23, 28, 29, 1946.

37. Dead Horse Mts., several miles east of Cooper's Store, collected Oct. 24, 1946.

38. Green Gulch, 3 miles south of Gov't Springs, Chisos Mts., collected Oct. 25, 1946.

39. Pass at top of Green Gulch en route to Chisos Basin, collected Oct. 25, 1946.

40. South Base of Pulliam Bluff, Chisos Basin, collected Oct. 26, 1946. Elevation ranging from 6000 to 7000 feet.

41. Chisos Basin, collected Oct. 27, 1946.

42. Hillside, 5 miles south of Chisos-Boquillas road junction, Oct. 28, 1946.

43. Creosote-leucophyllum mesa, 5 miles north of Hot Springs, Oct. 28, 1946.

44. 10 miles west of Valentine, collected Oct. 30, 1946.

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Glossary of Terms

acute—sharply pointed.
annuli—small dots or rings.
antennae—paired, thread-like appendage attached near the eyes and of varying lengths.
apex—tip.
apterous—without vestige of wings.
arboreal—dwelling in trees.
arcuate—arched or bowed in outline.
arenicolous—dwelling in sandy areas.
bifurcate—forked.
brachypterous—having small or rudimentary wings unfit for flight.
cactophilous—living in clumps of cacti.
calcariae—large curved spurs situated at the internal apex of the hind tibiae.
campestrian—dwelling in grasses or meadows.
carina—a keel or ridge usually on the pronotum.
carinate—provided with a carina or carinae.
caudal—referring to posterior part of the body.
cercus—one of a paired appendage usually of small size found on the genitalia of Orthoptera and usually situated just below the supra-anal plate.
cespitose—low creeping habit of certain plants.
concolorous—of the same general color.
crenulate—of wavy outline.
cristate—raised into a crest.
cursorial—legs adapted for running.
deserticolous—dwelling in the desert.
deserto-campestrian—living in a desert type of sparse grasses.
detritus—living in or under vegetational debris collected around plants on the edges of washes or arroyos.
dimorphic—having two forms.
domiciliary—living in houses.
ectogene—a species found outside its zone of optimum abundance.
ecotone—an area where two vegetational types merge together.
edaphic—referring to soil or type of soil.
endogene—a species found within its zone of optimum abundance.
ensiform—sword-shaped; referring to the form of the antennae.
fastigium—that pointed or rounded portion of the vertex projecting in front of the eyes of orthopterans.
fauna—a group of animal species having the same general life habits, dwelling in the same general area under the same climatic conditions, and possessing the same general geographic distribution.
fasciae—transverse bands crossing the wings or legs.
filiform—thread-like or of equal diameter, referring to antennae.
foveolae—a pit or shallow depression on the fastigium of grasshoppers and usually referred to as the lateral foveolae of the fastigium or vertex.
frontal costa—a prominent vertical ridge in grasshoppers running from the fastigium down between the bases of the antennae to the lower portions of the face.
genitalia—the mating organs.
habitat—the place inhabited by an insect or the type of locality where a species is captured.
macropterous—large-winged, usually referred to brachypterous species.
megacephalic—big-headed or head larger than normal.
metazona—posterior portion of the pronotum behind the median sulcus.
nacreous—mother-of-pearl coloration.

Nearctic—pertaining to the fauna of temperate and arctic North America.
oedipodine—a member of the Oedipodinae or band-winged grasshoppers.
ovate—oval or somewhat circular in outline.
pronotum—the collar-like structure behind the head of orthopterans.
prozona—the anterior portion of the pronotum in front of the median sulcus.
prosternal spine—a cone or heavy spine situated between the forelegs of certain groups of grasshoppers.
raptorial—legs adapted for grasping prey.
retrorse—bent backwards, referring to the prosternal spine.
rugose—with raised ridges or wrinkled.
saltatorial—referring to legs adapted for jumping.
saxi-arenicolous—rocky and sandy areas of arroyos.
saxi-campestrian—inhabiting gravelly grass areas.
saxicolous—dwelling in gravelly or stony areas or habitats.
sellate—saddle-shaped, referring to the pronotum.
serrate—like the teeth on a saw in general appearance.
spiracle—a breathing pore through which air enters or leaves the body of insects by means of the tracheae or air-tubes.
stridulation—the sound produced by certain orthopterans to attract the opposite sex of the species.
subgenital—the plate underlying the genitalia.
sulcate—grooved.
sulcus—a groove or crease.
supra-anal—the triangularly-shaped plate lying above the genitalia.
sylvan—a species living on the leafy floor of a forest.
tarsus—the foot or jointed appendage attached to the apex of the tibia and bearing claws or ungues and pad or pulvillus at its end.
tectate—roof-like.
tegmina—the narrow thickened first pair of wings that protect the flying wings in Orthoptera (singular-tegmen).
terricolous—dwelling on bare earthen areas.
thamnophilous—dwelling in shrubs or bushes.
troglodytic—dwelling in caves or burrows of rodents.
truncate—cut off squarely or obliquely at the tip.
vertex—top of the head between the eyes.

Detailed Faunistic and Ecological Studies on the Big Bend Orthoptera

KEY TO THE FAMILIES OF ORTHOPTERA OF TRANS-PECOS TEXAS

1. Hind legs constructed for jumping ..... **Saltatorial Orthoptera** 2
   Hind legs constructed for running or walking ..... **Cursorial Orthoptera** 6
2. Completely apterous, body humped—Camel crickets ..... GRYLLACRIDIDAE
   Winged, although tegmina and wings often abbreviate 3
3. Tarsi three-segmented 4
   Tarsi four-segmented, antennae longer than the body ..... TETTIGONIIDAE
4. Pronotum extending to the apex of the abdomen ..... TETRIGIDAE
   Pronotum normal, not extending to apex 5
5. Antennae shorter than the body—Grasshoppers ..... ACRIDIDAE
   Antennae longer than the body—Crickets ..... GRYLLULIDAE
6. Body ovalish in outline, depressed, pronotum shield-like and covering the head; wings present in males, often absent in females; legs compressed and spiny; cerci jointed; rapidly running insects—Cockroaches ..... BLATTIDAE
   Body elongate, head free; pronotum narrow and elongated; legs slender; walking

insects 7
7. Forelegs raptorial, fitted for grasping; cerci jointed ..... MANTEIDAE
Forelegs simple, cerci without joints, Stick insects ..... PHASMIDAE

The BLATTIDAE

Despite their very great antiquity which dates back to Devonian times, the Blattidae or cockroaches appear be be quite capable of taking care of themselves for many domiciliary species have spread all over the civilized world. A study of the distribution of such species as *Blatta orientalis*, the Oriental roach, would reveal much concerning the fascinating old trade routes of the world. The desert inhabiting species of the subfamily Polyphaginae are interesting creatures but the domiciliary ones are rather disgusting at best.

KEY TO THE MALES OF TRANS-PECOS BLATTIDAE

1. Size large, dark brown in color ..... *Periplaneta americana*
Size medium to small 2
2. Size medium, usually pale gray in coloration, female wingless 3
Size small, usually tan in coloration, females winged 4
3. Body and wings soft gray; tegmina pale, minutely dappled with dark gray along certain veins ..... *Arenivaga erratica*
Body and wings pale brownish gray, tegmina almost transparent ..... *Eremoblatta subdiaphana*
Size larger, almost one inch long; body reddish brown, pronotum dark with pale anterior margin ..... *Arenivaga grata*
4. Uniformly tan in coloration ..... *Parcoblatta desertae*
Two black bands longitudinally on pronotum ..... *Blatella germanica*
Pronotum dark in center with transparent margin; tegmina with pale cross-streak in basal third ..... *Supella supellectilium*

BLATTINAE

BLATTELLA GERMANICA (Linnaeus)

The German cockroach is a cosmopolitan species that is a pest in the Valley.

PARCOBLATTA DESERTAE Rehn and Hebard

Presidio, 5, V, 30, 1 ♂ (taken from Pink Bollworm hibernation tray).

This very small species, represented by a single male, was described from Valverde County and recorded from Ft. Davis and the Chisos Mountains by Hebard, in 1917. The Presidio specimen appears to represent the southwestern distributional point of this species. Mr. J. H. Russell, who has been for many years stationed with the Customs Service at Presidio, has taken a few additional specimens at light.

SUPELLA SUPELLECTILIUM (Serville)

Presidio, Oct. 1946 (infesting houses).

Within the past fifteen years this small Sudanese roach has spread all over the southern portions of the United States. It was found first in Arizona, in 1933, and spread from there into California although the initial introduction was probably through New Orleans. It was definitely not present at Presidio,

in 1928 to 1930, but was a common pest there in 1946. The egg parasite, the small wasp *Anastatus blattidarium* Ferriere plays a considerable rôle in the control of this important household pest.

PERIPLANETA AMERICANA (Linnaeus)

This large and annoying pest of pantry and cookhouse has established itself in almost every country of the globe.

POLYPHAGINAE

ARENIVAGA ERRATICA Rehn

Presidio, 16, IX, 29, 6 ♂♂; 10, IX, 28, 2 ♂♂; 20, X, 46, 3 ♂♂.

This species is deserticolous; the males are commonly attracted to light while the oval wingless females are found under vegetational debris or in the burrows and dens of rodents. This species is generally distributed over the desert regions from the Pecos River west to southern California and north to Santa Fe, Durango, Colorado, and southern Utah. It is an inhabitant of the Lower Sonoran Zone.

ARENIVAGA GRATA Hebard

Hebard, in 1943, records this large and interesting species for the first time from Texas. Previously it was known only from the type locality, the Baboquivari Mountains of south-central Arizona.

The Texas specimens were taken by Mr. F. M. Gaige in July, 1928, at Juniper Canyon and Juniper Springs in the Chisos Mountains. These were taken in scrub oak, oak-pine and oak-manzanita forests under stones and rocks.

Arenivaga grata appears to be a member of the Mexican Upper Sonoran fauna since its distribution is closely similar to the other members to be later discussed, namely, *Achurum sumichrasti, Amblytropidea mysteca, Rhammatocerus v. viatoria* and *Amblycorypha insolita. A. grata* should be found at appropriate elevations in the Chinati Mountains.

ARENIVAGA TONKAWA Hebard

Presidio, May 5, 1945, 1 ♂ (J. H. Russell).

During the past seventeen years that Mr. Russell has been with the Custom's Service at Presidio, he has collected many new species, rarities and records. This specimen, identified by Dr. H. K. Townes, appears to be the first record for Trans-Pecos Texas. In 1932b, Hebard first recorded the species from Mexico in a male taken at Nuevo Laredo, Tamaulipas.

A. tonkawa has an extensive distribution in south-central Texas and appears to be a member of the Tamaulipan Semi-desert Bushland fauna.

EREMOBLATTA SUBDIAPHANA (Scudder)

Presidio, 9, IX, 28, 1 ♂; 15, V, 30, 2 ♂♂; 16, V, 30, 1 ♂.

This light tan colored species with semi-transparent tegmina is closely similar to *P. desertae* but about twice its size. It is a member of the Lower Sonoran Faunal Zone and is known from southern California east to Presidio

and Castalon. Castalon in the Rio Grande Valley south of the Chisos represents the eastern limits of this species.

Eremoblatta n. sp.

Mr. J. H. Russell of Presidio has informed me that he has taken a new species of *Eremoblatta* at Presidio in recent years, the description of which may soon appear at the United States National Museum.

The MANTEIDAE[1]

The praying mantids, often called "Devil Horses," are fairly well represented in the Big Bend Region. They capture prey with their powerful, raptorial forelegs and are entirely cannibalistic in habits. Their eggs are laid in large, tough, fibrous, egg masses and these are often observed on the stems of desert shrubs where they remain for many years.

KEY TO THE SPECIES OF MANTEIDAE OF TRANS-PECOS TEXAS

1. Eyes normal in outline 2
   Eyes projecting forward in conical points ..... *Yersiniops solitarium*
2. Small to medium sized mantids 3
   Very large mantids green in coloration 4
3. Small mantid, grey in color; females brachypterous, males either macropterous or brachypterous ..... *Litaneutria minor*
   Medium sized mantids of elongate and slender build ..... *Oligonicella scudderi*
4. Males with three or four black bars on the dorsum of the abdomen; females with fan-like smoky wings ..... *Stagmomantis californicus*
   Males without black abdominal bars; fan-like wings of females lemon yellow with clearer rectangular patches ..... *Stagmomantis limbata*

AMELINAE

YERSINIOPS SOLITARIUM (Scudder)

12 miles north of Marfa, 29, IX, 31, 1 ♀.

Until recently this species has been known in the literature as *Yersinia solitaria* Scudder. Hebard, in 1931b, erected the new genus *Yersiniops* to include *solitaria*, the genotype, *sophronica* R. & H., and a newly described species *newboldi* Hebard; restricting *Yersinia* to the species *mexicana* (Saussure).

Y. solitarium is a member of the Southwestern Grasslands fauna of the Upper Sonoran Zone, its range extending from southern Colorado south over the grasslands of New Mexico to the Baboquivari Mountains of Arizona and the Davis Mountains of Trans-Pecos Texas. Hebard, 1943, recorded the first Texas specimens from the Davis Range which included six males and six females (21), taken by the writer in 1931.

LITANEUTRIA MINOR (Scudder)

Davis Mts., 4, X, 29, 1 ♀. Presidio, 20, X, 28, 1 ♂. South base Pulliam Bluff, Chisos Basin, 24, X, 46, 1 ♀.

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1 The family name is formed by adding *idae* to the stem of the word, which of *mantis*, is *mante* from the genitive singular *manteus* (Roberts 1941b.).

Many synonyms of this variable species exists; thus *longipennis* Beier, and *ocularis* Saussure, represent species based on the macropterous males; *skinneri* Rehn, described from a brachypterous male and *pacifica* Scudder, and *obscura* Scudder, represent obscurely colored individuals of the species.

L. minor is a member of the Southern Short Grasslands fauna of the Upper Sonoran and its range extends from northern Montana and southwestern North Dakota east to Iowa, central Kansas and central Texas, south to northern Mexico, and west to Arizona, California, and northwest to Washington and Osoyoos, British Columbia.

OLIGONICINAE

OLIGONICELLA SCUDDERI (Saussure)

This interesting brachypterous "Stick Mantis" has been recorded by Hebard (1943) from Marfa, Marathon and the Chisos Mountains. No specimens were taken by the writer of this rather rare mantid.

This species appears to belong to the Southwestern Grasslands fauna of the Upper Sonoran although its range is not clearly defined at present.

MANTEINAE

STAGMOMANTIS CALIFORNICA Rehn and Hebard

Chinati Mts., (2), 30, IX, 29, 1 ♀ (elev. c. 5200 ft.). Presidio, 1, IX, 29, 1 ♂.

This large mantis is known from Trans-Pecos Texas westward throughout New Mexico and southern Arizona to Bakersfield, California, north to Indian Springs and Millers, Nevada, southwestern tip of Utah and Grand Junction, Colorado.

This species is an inhabitant of the Lower Sonoran Faunal Zone and is found throughout the creosote deserts of the Southwest.

STAGMOMANTIS LIMBATA (Hahn)

Presidio, 17, VIII, 29, 1 ♀; 12, IX, 28, 1 ♂.

This large mantis is usually more abundant than *S. californica* and in the late summer males of this species come commonly to car lights in the southwestern deserts. The females are quickly recognized by the yellow fan wings and the males lack the four abdominal black bars characteristic of the males of *californica*.

In the southwestern United States the northern limits of the range of this species do not extend quite as far north as that of *californica* and in the west extends little beyond the Colorado River. South, however, its range is extensive and widespread throughout Mexico and south to Guatemala.

The PHASMIDAE

The Phasmidae or stick insects or Walking Sticks are curious creatures of slow and deliberate movement that spend their lives in bushes or in grasses. Their eggs are single resembling seeds or miniature jugs with variously shaped lids. Of the thirteen species found in Texas, seven are found in Trans-Pecos Texas.

KEY TO THE PHASMIDAE OF TRANS-PECOS TEXAS (after Hebard)

1. Antennae very short, about the length of the head; form slender; dwelling in grasses ..... *Parabacillus coloradus*
   Antennae very long and slender 2
2. Median femora without a ventral apical tooth ..... *Pseudosermyle straminea*
   Median femora with a ventral apical tooth or teeth 3
3. Ventral median carinae of middle or middle and caudal femora spined throughout their length; male cerci spathulate ..... *Megasphama denticrus*
   Ventral and median carinae of median or median and caudal femora armed with only a single apical tooth; male cerci not spathulate ..... *Diapheromera* (4)
4. Males and females with a pair of prominent occipital horns between the eyes; lives on creosote; L. Sonoran ..... *D. covilleae*
   Males and females without occipital horns 5
5. Form very slender; male cerci without an internal basal tooth; Oak or Upper Sonoran Zone in Chisos ..... *D. torquata*
   Form more robust; male cerci with an internal basal tooth 6
6. Male cerci with a minute acute internal basal spine; femora without narrow dark cross bands; ground herbage and mesquite ..... *D. velii eucnemis*
   Male cercus with a small bluntly rounded internal basal flange; femora usually with narrow cross bands; oaks and deciduous trees and shrubs; Upper Sonoran Zone ..... *D. femorata*

PACHYMORPHINAE

PARABACILLUS COLORADUS (Scudder)

Ft. Davis, Jeff Davis Co., 14, X, 1946, 1 ♀ (grassy mt. slope).

One specimen of this species was taken by the writer and Hebard (1943) has recorded it from various places in the Chisos Mts., western foothills of the Ord Mts., Pine Mt. and Mt. Livermore in the Davis Range and Ft. Davis, Marfa, Marathon and Sanderson.

This very short-antennaed, slender, grass-loving species is an inhabitant of the Upper Sonoran Zone and its known distribution extends west of Sanderson and Canadian in Texas, to the Hualpai Mts. of northwestern Arizona, ranging north to eastern Utah, Wyoming and South Dakota.

HETERONEMIINAE

PSEUDOSERMYLE STRAMINEA (Scudder)

Marathon, Brewster Co., 21, X, 1946, 3 ♂♂ (at light).

Hebard (1943) reports this species from the Chisos and Davis Mountain regions, Marathon, Sanderson, Ft. Davis, Kent, Van Horn and Sierra Blanca.

Its range extends east from Trans-Pecos Texas to Weatherford, Texas, Kenton, Oklahoma and north to La Junta, Colorado, Tesuque, New Mexico and the Wah Wah range in Utah. Northwest it is found throughout most of Arizona to Walker's Lake, Nevada, and Independence, Riverside and Boulevard in California. Its altitudinal range is great and occupies both Lower and Upper Sonoran Faunal Zones.

MEGAPHASMA DENTRICUS (Stål)

This species has been found west of the Pecos only in the Chisos Moun-

tains although more detailed work at higher elevations in the Chinatis, particularly Chinati Peak, should reveal it to be there.

From the Chisos Mountains Hebard reports its ranges east to Opelousas, Louisiana, Joplin, Missouri and Henryville, Clark County, Indiana, and north to Ft. Dodge, Iowa and Garnett, Kansas. Western limits are the latter locality, Latimer County, Oklahoma and the Chisos.

DIAPHEROMERA COVILLEAE Rehn and Hebard

Twenty miles north of the Chisos, 18, VII, 1930, 1 ♂ (E. R. Tinkham; Hebard Cln.). Rio Grande Valley near Presidio. Ten miles north of Toyahvale, Texas, 23, X, 43, 1 ♀ (in creosote). Malaga, N. Mex., 12, X, 1946, 2 ♂♂.

Though restricted to the creosote bush (*Larrea divaricata*) this species is not coextensive with the range of its host plant. Its abundance is varying and scattered.

This species is not found east of the Pecos River and from there it ranges west over the creosote areas of the desert to Ajo and the Growler Valley, south of Ajo (Mearn's Line) and north and northwest to the south base of the Mogollon Plateau in Arizona and Kingman, Arizona. In New Mexico its northern limits are Carlsbad, Alamogordo, and the Hachita Grande Mountains. In Mexico it has been recorded only from Jaral and the Sierra del Tiahualilo, in the state of Coahuila. *D. covilleae* is a member of the Chihuahuan fauna of the Lower Sonoran.

DIAPHEROMERA TORQUATA Hebard

This species was described by Hebard, in 1934, from the Canyon behind Pulliam Bluff and Lost Mine Peak in the Chisos Mountains, which is the type locality of this rare species. No additional specimens have been taken. The species was taken in high grass, oak brush, low acacias and a profusion of other plants in the oak zone of the Chisos range.

D. torquata is undoubtedly a member of the Chihuahuan Upper Sonoran fauna and at present its range is known to be very local in nature.

DIAPHEROMERA VELII EUCNEMIS Hebard

Mesa 15 miles north of Presidio (reported by Hebard). 3 miles East of Alpine 22, X, 1946, 1 ♂ (*Acacia greggii*).

In 1937, Hebard described this race to represent the Lower Sonoran development of *velii* found primarily in the Rio Grande Valley although in New Mexico intrusions of the nominal race *D. velii velii* occur. However in Trans-Pecos Texas *D. v. eucnemis* typically occurs.

Hebard records this species from the Chisos and Ord Mountains, Valentine, Marathon and Van Horn which are also northern limits. Additional northern limits include, Del Rio, Sabinal, Cotulla and Corpus Christi and Deming in New Mexico. South in Mexico it is known only from Salinas Hidalgo in Nuevo Leon where an optimum condition occurs.

D. v. eucnemis is a member of the Chihuahuan fauna of the Lower Sonoran Zone.

DIAPHEROMERA FEMORATA (Say)

No specimens of this species were taken by the writer but Hebard (1943) has recorded it from various localities in the Chisos Mountains, as well as the Ord Mountains and the Davis Range. Its favorite food plant is scrub oak.

West of these areas in the Big Bend Region *D. femorata* has been taken at Bent, Three Rivers, west base of the Organ Mountains, Jemez Hot Springs and Hachita Grande Mountains in New Mexico to Paradise, Naco and the Baboquivari Mountains in Arizona. East it ranges to the Atlantic in northern Florida, north to South Bridgeton, Maine, central Ontario, Iosco and Crawford counties in Michigan, Selkirk, Manitoba and Grand Forks, North Dakota. Its western limits in the north central states is marked by the eastern edge of the prairies, south to Dallas, Texas.

Hebard believes that *D. femorata* is an ancient species of the Rocky Mountains that has spread to widely separated localities. It could also be a member of a one-time early fauna that enjoyed a much greater extensive range, but changing climatic conditions have probably exterminated its host plant over vast areas of the southwest so that today it is found only in certain isolated mountain regions of the Southwest where oaks survive.

D. femorata is undoubtedly a member of the Upper Sonoran Faunal Zone that finds its optimum life conditions in the more humid eastern sections of the United States where Oaks are the dominant forest trees.

The TETRIGIDAE

The Tetrigidae, known as grouse locusts, are easily rocognized by the prolongation of the pronotum over the abdomen and by their short fine antennae and small size. Being lovers of damp sand or soil they are necessarily restricted to the vicinity of streams and seepage areas in the southwestern deserts.

KEY TO THE SPECIES OF PARATETTIX

Body color black; face with white band on lower portions; pronotum extending beyond tip of abdomen; form slender ..... *aztecus* (Sauss.)

Body color brownish; form short and stout; tegmina not extending beyond apex of abdomen ..... *mexicanus*

PARATETTIX AZTECUS AZTECUS (Saussure)

Chupadero Ranch, 6 miles northeast Presidio, 4, IX, 29, 3 ♀♀ (muddy bank of ditch). Davis Mts., Cox's Ranch at south base Mt. Livermore, 29, IX, 31, 1 ♂, 3 ♀♀ (along stream bed at about 7000 ft. elev.).

Synonyms: aridus Hancock and *parviverticis* Hancock.

This small and interesting grouse locust has a wide range in the southwestern United States extending from Texas to Arizona and California and south to Mexico.

PARATETTIX MEXICANUS MEXICANUS (Saussure)

Presidio, 27, I, 29, 1 ♀ (along banks of the Rio Grande). Dawson's Ranch, 6 miles southeast Shafter, 8, VII, 29, 1 ♂, 3 ♀♀ (around spring). Bofecillos Mts., 20 miles east Presidio, 4, VII, 29, 2 ♀♀ (stream bed). Chupadero Ranch, 6 miles north-

east Presidio, 4, IX, 29, 2 ♀♀ (ditch bank). Dead Horse Mts., Brewster Co., east of Cooper's Store, 23, Oct. 1946, 1 ♀ (edge of dam).

Hebard, in 1932, placed *P. mexicanus abortivus* Hancock, *P. toltecus sonorensis* Hancock, *P. tuberculatus* Hancock, and *P. toltecus* (Saussure) as synonyms of this species. Until recently this species has been referred to as *P. toltecus*.

P. m. mexicanus has a wide range from the southern border of the United States south to Panama.

The ACRIDIDAE

KEY TO THE SUBFAMILIES OF TRANS-PECOS ACRIDIDAE

1. Face strongly receding so that the vertex is angled sharply with the front of the face ..... ACRIDINAE (pt.)
   Face more or less vertical so that the vertex is more or less broadly rounded into the face 2
2. All species fully winged; wings brightly colored and banded 3
   Species either fully winged or with tegmina pad-like; if fully winged, wings are transparent or amber, never banded 4
3. Prosternum without a spine ..... OEDIPODINAE
   Prosternum with a spine ..... ROMALEINAE
4. Prosternum spined ..... CYRTACANTHACRINAE
   Prosternum unspined 5
5. Pronotum normal in form; outer apical spine of the caudal tibiae absent ..... ACRIDINAE (pt.)
   Pronotum greatly enlarged, flattened dorsally and caudally produced; caudal tibiae with outer apical spine present ..... PAMPHAGINAE

ACRIDINAE

The Acridinae are known as the "Slant-faced Grasshoppers" although not all genera of the subfamily as now understood are slant-faced. Many of the genera are long and slender with strongly receding faces, but other such as *Boopedon* and *Aulocare*, etc., have heads closely resembling the oedipodines and save for the cutting of the pronotum are not easily distinguished from them. In fact *Heliaula* has been placed in both subfamilies at various times; the egg and certain aberrant features, however, indicate that it is a member of the Acridinae. Even more striking is the case of *Eremiacris* which has been removed from the Cyrtacanthacrinae by the writer and placed in the Acridinae. Despite the false prosternal spine which appears to be due to the pinching of the pronotum to adapt it to its grass-blade habitus, other features and a study of the egg indicate that it is an acridine. With the exception of *Aulocara elliotti* most of the Acridinae are not considered very injurious species.

KEY TO THE GENERA OF THE ACRIDINAE OF TRANS-PECOS TEXAS

1. Face receding strongly to form a sharp angle with the fastigium of the vertex, the lateral foveolae or pits of the fastigium invisible from above 2
   Face usually vertical and rounding above into the vertex so that the lateral foveolae are visible from above 15
2. Form long and slender; antennae decidedly ensiform 3
   Form more robust and less elongated; antennae filiform 5

3. Apex of tegmen acutely pointed ..... *Achurum*
Apex of tegmen truncately rounded 4

4. Prosternum armed with a slender process ..... *Eremiacris*
Prosternum without a process or spine ..... *Mermiria*

5. Metazona of the pronotum arcuately cristate; color green; tegmina green with yellow blotches; wings yellow with black bands ..... *Acrolophitus*
Metazona of the pronotum flat 6

6. Vertex strongly elevated with apex angled with the face; pronotum in profile subsellate; wings shining black ..... *Pedioscirtetes*
Vertex not strongly elevated; pronotum not subsellate; wings pellucid except in *Syrbula* 7

7. Color green with nacreous pronotal markings ..... *Bootettix*
Color not as above 8

8. Lateral carinae of pronotum straight; inner calcariae of caudal tibiae long; antennae slightly ensiform ..... *Opeia*
Lateral carinae of pronotum variably constricted in the middle 9

9. Inner calcariae of caudal tibiae large and decidedly unequal 10
Inner calcariae of caudal tibiae equal in length 11

10. Lateral carinae strongly constricted in the middle; tegmina and wings not extending to apex of abdomen; tegmina with four crenulate markings ..... *Phlibostroma*
Lateral carinae not strongly constricted; tegmina extending to apex of abdomen and with a black median dash broken by several light lines ..... *Eritettix*

11. Spines of caudal tibiae 12 to 15 in number 12
Spines of caudal tibiae 16 to 24 in number ..... *Syrbula*

12. Fastigium of the vertex with surface largely convex and lacking a conspicuous impression; median carina distinct 13
Fastigium of the vertex with the surface flat or concave with a conspicuous impression; median carina indistinct 14

13. Lateral carinae of pronotum indistinct and curved; color brown striped with cream ..... *Amphitornus*
Lateral carinae of pronotum distinct and nearly straight; color uniformly brown or brownish gray ..... *Amblytropidea*

14. Size small; lateral carinae of the pronotum indistinct ..... *Cordillacris*
Size medium; lateral carinae of pronotum distinct ..... *Orphulella*

15. Fore margin of tegmen convex with the marginal area with many diagonal cells crossed by subcostal vein; sexes similar ..... *Goniatron*
Fore margin more or less straight without diagonal marginal cells; sexes dissimilar 16

16. Antennae very long and ensiform; color grayish ..... *Acantherus*
Antennae short and usually filiform 17

17. Median carina of the pronotum distinct 18
Median carina of the pronotum obsolete ..... *Heliaula*

18. Caudal tibiae deep bluish 19
Caudal tibiae reddish 20

19. Tegmina and wings shorter than abdomen; color pale with dark markings on pronotal lobes and fasciations on caudal femora conspicuous ..... *Drepanopterna*
Tegmina and wings extending to apex of abdomen; color more uniformly gray ..... *Aulocara*

20. Tegmina mere ovate pads; size very small; color reddish ..... *Zapata*
Tegmina never ovate pads; size small to medium 21

21. Males shining black; females dimorphic, either black or greenish gray; caudal tibiae red and black ..... *Boopedon*
Males and females never black 22

22. Size large, lateral foveolae of vertex indistinct; wings considerably surpassing apex of abdomen ..... *Rhammatocerus*
Size small, lateral foveolae of the vertex distinct; wings not extending beyond apex of abdomen 23

23. Lateral carinae of pronotum distinct and strongly constricted in the middle; caudal tibiae buff or pink ..... *Psoloessa*
Lateral carinae of pronotum indistinct; caudal tibiae red ..... *Ageneotettix*

ACHURUM SUMICHRASTI (Saussure)

Chinati Mts, 6, VI, 30, 5 ♂♂, 4 ♀♀ (Tinkham Cln.), 3 ♂♂, 2 ♀♀ (Hebard Cln.), many nymphs present at the same locality on 4, V, 30. Chinati Mts., same locality, 8, VII, 30, 1 ♀. Green Gulch, Chisos Mts., 23, X, 46, 1 ♂ nymph.

A. acridodes Stål, is a synonym.

This rare speices was found in one particularly steep cut on the north slope of a high plateau at about 5500 feet elevation. Its habitat was limited to an altitudinal range of about 100 feet where it was found only in the tall grass in the bottom of the cut. This species has a curious habit of making short sudden jumps from grass stem to grass stem and then "freezing" or remaining rigid with its antennae aligned forward and pressed against the stem; their graceful form blending perfectly with their surroundings where they are almost impossible to locate unless disturbed.

It is interesting to note that in this particular habitat of rocky soil covered with an abundance of tall grass and an occasional sotol and sacahuiste clump (*Nolina texana*) (Fig. 24), two other species, namely *Rhammatocerus viatoria viatoria* and *Amblytropidea mysteca* were taken on the same day for the first time east of south-central Arizona, thus constituting first Texas records. These records with additional information help considerably to prove the close affinities existing between the Big Bend desert mountain fauna and that of the mountains of south central Arizona. Recent botanical exploration has indicated that these two faunae are connected *via* Coahuila and Chihuahua with the Sonoran fauna and not by way of the Sierra Madres Orientale as was formerly suspected.

This is the largest series of this species recorded from Trans-Pecos Texas; the species having previously been reported by Hubbell (1925) in a single female collected in Cherry Canyon, Davis Mts., VII, 9, 1916 by F. M. Gaige which constitutes a first Texas Record.

The range of *A. sumichrasti* extends south into Sonora from south central Arizona and southwesterly from the Big Bend Region through Coahuila and Chihuahua south to the Mexican states of Jalisco, Vera Cruz, Morelos, Guerrero and Chiapas.

EREMIACRIS VIRGATA (Scudder)

Elephant Rock, 28 miles north of Presidio, 3, IX, 28, 1 ♀ (tall desert grass). North edge Davis Mts., 12, X, 46, 1 ♂. 1 mile north Persimmon Gap, Brewster Co., Texas, 23, X, 46, 1 ♀.

This species is very rare in the Big Bend becoming more abundant to the north and east and northwest where habitats of taller grass are commoner.

In 1929, Hebard erected the genus *Eremiacris* to include several species previously assigned to the genus *Parapomala* Scudder, and made *virgata* Scudder, the genotype of *Eremiacris*. To this genus also belong *pallida* (Br.) and *acris* Rehn and Hebard, both found in Arizona. The members of this genus are long and slender, with ensiform antennae, strongly receding face and with the tegmina equalling or slightly surpassing the apex of the abdomen. Rehn and Hebard removed them from the Acridinae to the Cyrtacanthacrinae in 1904 where they have remained. Aside from the prosternal spine their features are typically that of the Acridinae and the prosternal spine appears to be the result of lateral compression on the prosternum to adapt it to its grass-blade habitus. This spine is slender and delicate and quite distinct from the heavy conical spine observed in most genera of the Cyrtacanthacrinae. However, the egg of *Eremiacris* is most revealing. It is long and slender with a papilliform type of cap similar to that in *Ageneotettix*, and *Aulocara* and practically devoid of sculpturation as observed also in *Aulocara, Drepanopterna, Ageneotettix, Zapata* and other genera of the Acridinae. From these studies the writer believes that *Eremiacris* should be removed from the Cyrtacanthacrinae to the Acridinae and placed near the genus *Mermiria*. The writer first indicated this placement in 1940, p. 275.

Virgata was described from Mesilla, New Mexico and Rehn and Hebard have recorded it from various places along the Rio Grande and from Lamar and Rocky Ford, Colorado, west to the eastern edge of Arizona. It appears to be a member of the Southwestern Grasslands fauna of the Upper Sonoran Zone.

KEY TO THE SPECIES OF MERMIRIA OF TRANS-PECOS TEXAS

1. Pronotum with lateral carinae absent ..... *m. maculipennis*
   Pronotum with lateral carinae present 2
2. Dorsal and lateral dark stripes prominent, separated by yellow; habitat, desert areas ..... *texana*
   Lateral stripe only prominent, yellow absent, high mountain grass ..... *neomexicana*

MERMIRIA TEXANA Bruner

Chinati Mts., 30, IX, 1928, 1 ♂; 29, X, 28, 1 ♂, 2 ♀♀; 4, VIII, 29, 1 ♂, 2 ♀♀; 27, IX, 31, 2 ♀♀; 1 ♂, 2 ♀♀ (Univ. of Minn. Cln.); 18, X, 46, 1 ♀. Bofecillos Mts., 4, VII, 29, 1 ♂. Davis Mts., 29, IX, 31, 1 ♀. 17 miles east of Marathon, 14, VIII, 40, 2 ♂♂, 1 ♀. Lower Limpia Canyon, 20 miles southwest Balmorhea, Jeff Davis Co., 12, X, 46, 1 ♂, 1 ♀. Green Gulch, Chisos Mts., Brewster Co., 24, X, 1946, 1 ♀. South base Pulliam Bluff, Chisos Basin, elev. 6000 ft., 25, X, 46, 1 ♀ 2 ♀♀. Hill five miles south road junction Chisos and Hot Springs, Brewster Co., en route Boquillas, 28, X, 1946, 1 ♂ (rare). Hueco Mts., 25 miles east El Paso, Texas, 9, X, 46, 2 ♂♂, 1 ♀ (mts. similar in flora to Chinatis).

N. texana is one of the commonest of the desert acridines being found everywhere in the Chinatis from about 4200 feet to 6000 feet on the slopes of Blue Mountain, one of the higher peaks. It is a member of the Lower Sonoran fauna extending upward into the lower reaches of the Upper Sonoran Zone. However, in Arizona it appears to be Upper Sonoran in range being found amongst the oaks of the Huachuca Mts. and the pines on the top of the Mingus Range near Jerome.

M. texana is found throughout the desert ranges of Trans-Pecos Texas southeast to the mountains northwest of Saltillo, Coahuila, and desert areas 20 miles north of Doctor Arroyo, San Luis Potosi. West of Texas it is found from the Huachuca to the Mingus Mountains of Arizona.

MERMIRIA NEOMEXICANA (Thomas)

Davis Mts., Perkins Ranch, 4, X, 29, 2 ♀♀ (elev. approx. 6500 in tall mountain grass. Lower Limpia Canyon, Davis Mts., 20 miles southwest Balmorhea, 12, X, 46, 1 ♂, 1 ♀. 3 miles east Alpine, Brewster Co., 22, X, 46, 1 ♂.

Tall grass on a mountain slope with scattered pines on the approaches of Mt. Livermore from the northeast was the habitat of this rare species. A thorough day's collecting by the writer and his brother on September 29, 1931 on the southern slope of Mt. Livermore failed to reveal this species even at elevation of 8000 feet.

From the Davis Mountains this species ranges west through New Mexico to the Baboquivari Mts. of Arizona and north and northeast to northern Colorado and southern South Dakota and Iowa and Illinois. *M. neomexicana* appears to be restricted to the Upper Sonoran Zone and these appear to be the first records for the Big Bend Region.

MERMIRIA MACULIPENNIS MACULIPENNIS Bruner

Presidio, 6, IX, 29, 1 ♀. 9 miles east Marfa, Presidio Co., 29, X, 46, 1 ♀.

This solitary Presidio specimen was taken in tall coarse grass that grew in a damp spot near a well. Two years of extensive collecting failed to locate it elsewhere. Agricultural conditions due to man's activity have aided the establishment of this species and others such as *Schistocerca americana.*

This species is commonly found in southeastern Arizona where its preferred habitat is swales of Sacaton grass (*Sporobolus wrighti*) although tall coarse grasses such as *Sorghum halepense, Elymus* sp. and *Andropogon* sp. are attractive. From southeastern Arizona *maculipennis* ranges east to the Big Bend region and northeast to northern Texas where it intergrades with the northern race *macclungi.* Hebard, in 1932, recorded *maculipennis* from Jimenez, Chihuahua, Mexico. It is a member of the Southwestern Grasslands fauna of the Upper Sonoran.

BOOTETTIX ARGENTATUS Bruner

Ruidoso Hot Springs, 18, IX, 28, 4 ♂♂, 1 ♀. 12 miles north of Presidio, 30, IX, 28, 2 ♂♂, 1 ♀ (mesa); 1 ♂ (Univ. of Minn. Cln.). 20 miles north of Chisos Mts., Brewster Co., 18, VII, 30, 1 ♂, 1 ♀; 5 ♂♂, 1 ♀ (Hebard Cln.). 7 miles east Sierra Blanca, 13, VIII, 40, 2 ♂♂, 1 ♀. Jimulco, Mexico, Nov. 2 ♀♀ (Univ. of Minn. Cln.). 4 miles west Salt Flats, Hudspeth Co., Texas, 9, X, 46, 1 ♂, 3 ♀♀.

This characteristic endogene of the Chihuahua Desert is found wherever its food plant *Larrea divaricata* occurs. Its rapidly stridulated *Bispt-Bispt-Bispt* is heard continuously throughout the night and throughout the year, for it is an annual form. Its green coat with nacreous markings blends the creosote grasshopper perfectly into the glistening lights and dark green shadows produced by the leaves of *Larrea* in sunlight.

B. argentatus ranges over the entire Chihuahua Desert, from the valleys of the Pecos and the Rio Grande and Otero Basin south over the creosote sections of northeastern Mexico. It is common in southern Coahuila from the Sierra de Parras to 20 miles northwest of Saltillo. On the Sonoran Desert of Arizona, California and Sonora this species is replaced by its near relative *Bootettix punctata* Scudder. Both species are indicators of the Lower Sonoran Faunal Zone.

PEDIOSCIRTETES MACULIPENNIS (Scudder)

Chinati Mts., (1), 30, IX, 28, 2 ♂♂, 1 ♀; 6, VII, 29, 1 ♀ (Univ. Minn. Cln.); (3), 16, IX, 29, 2 ♂♂, 2 ♀♀; 8, IX, 29, 1 ♂, 1 ♀ (Minn. Cln.); (3), 23, IX, 29, 2 ♂♂; 1 ♂, 2 ♀♀ (Minn. Cln.). Bofecillos Mts., 20 miles east Presidio, Presidio Co., 4, VII, 29, 1 ♀ (elev. c. 4300 ft.). 20 miles north of Chisos Mts., Brewster Co., 18, VII, 30, 1 sp. (Hebard Cln.). 23 miles south Cooper's Store, Brewster Co., 28, X, 46, 1 ♂ (seen in road). 11 miles north Pecos, Reeves Co., 12, X, 46, 1 ♂. Laredo, Texas, 1938, 1 ♂ (R. H. Crandall). 17 miles east of Marathon, 14, VIII, 40, 1 ♂.

The synonym *Acrocara* was established by Hebard in 1926.

This large black-winged, mottled grayish and blackish acridian with sellate pronotum and acutely apexed head is one of the most interesting and conspicuous of Chihuahuan Desert Orthoptera. It is a rare species in Texas and in all my hunting only two small communities at (1) and (3) were found in the Chinati Mountains. Although the community on top of the hill at (1) a valley about 2 miles south of Shafter by the new paved road, was searched on October 18, 1946, not a specimen was found there, nor west of Shafter on Oct. 19, due apparently to the lack of the usual summer rains in July. The habitat at (1) appeared to be a patch of dwarf *Dahlia Parryi* bushes which may have been the host plant. West of Shafter, several miles, at (3) the colony was located on a small patch of gravel with a fair coverage of short grasses. Associated with it was *Dactylotum variegatum* (few), *Phrynotettix robustus* (rare) while *P. maculipennis* was present in fair numbers.

P. maculipennis enjoys a wide but discontinuous distribution over the Chihuahuan Desert. From the Big Bend Region it extends north up the Pecos Valley into New Mexico, and westward to the extreme southeastern corner of Arizona where its range swings around the north side of the Chiricahuas to Dos Cabezas and south to Tombstone, in typical Chihuahuan Desert floral habitats. Eastward and southward its range extends to Laredo and the desert areas of northeastern Mexico. The writer found it common, 13 miles northwest of Monterey on August 16, 1940 and the nymphs were abundant at Gomez Frias in southern Coahuila on August 21, 1940, at elevations of 6200 feet on the Salado Desert, the southern subdivision of the Great Chihuahuan Desert.

ACROLOPHITUS VARIEGATUS Bruner

Marfa, 29, VI, 30, 1 ♂, 7 ♀♀. 15 miles north of Marfa, 28, IX, 31, 1 ♂. Eastland Co., Texas, May 14-30, 1921, 2 ♂♂ (Grace Wiley; Univ. of Minn. Cln.).

This is the largest acridine of the region. Possibly no other acridid with the exception of the oedipodine *Tropidolophus formosus*, which it somewhat

resembles, bears a more unusual appearance. Its entire body surface is rich green, densely hirsute, with yellow mottlings on the tegmina and a black band outwardly margining the yellow discs of the wings. It is unique in the Acridinae in possessing a very high median metazonal crest.

A. variegatus is a member of the Southwestern Grasslands fauna of the Upper Sonoran Zone. The Marfa specimens were taken on stony ground with a sparse coverage of grass about six miles east of that town. The species ranges northeast to the southern border of Kansas where it is replaced by the northern species *A. hirtipes* whose distribution extends north to southern Alberta. It has not been taken in Arizona.

SYRBULA FUSCOVITTATA (Thomas)

Chinati Mts., 30, IX, 28, 1 ♀ (tall grass). Presidio, 24 VIII, 29, 1 ♀ (attracted to light). Chinati Mts., (3), 16, IX, 29, 5 ♂♂, 3 ♀♀; (7), 27, IX, 31, 1 ♂ (Univ. of Minn. Cln.) (few to common at elev. of 5200 to 5700 ft.). Six miles northeast of Ft. Davis, 12, X, 46, 1 ♀. Springs 20 miles south of Marathon, Brewster Co., 22, X, 46, 1 ♀. Pass at summit Green Gulch to Chisos Basin, Chisos Mts., 24, X, 46, 1 ♂, 1 ♀ (elev. c. 6500 ft.). South base of Pulliam Bluff, Chisos Basin, 25, X, 46, 1 ♂, 1 ♀ (elev. c. 6000 ft.).

Synonyms: acuticornis Br., and *modesta* Br.

The wings of this species are black in the male and smoked amber in the females. The males are considerably smaller than the larger and usually greener females. Their habitat is tall grass on mountain slopes or valleys where the *tsck-a-tsck-a-tsck* of the male is often heard.

S. fuscovittata is a member of the Southwestern Grasslands fauna of the Upper Sonoran Zone. From the Big Bend Region its range extends to central Arizona, north to Canyon City, Colorado and northeast into central Texas. It has not been recorded from Mexico.

Several unlabelled specimens of *Syrbula admirabilis* were given me by a friend from southwestern Texas, but I do not know whether or not they came from the Big Bend Region. It is possible that this species may be found at higher altitudes in the Davis Mountains or along the Pecos Valley.

OPEIA IMPERFECTA Bruner

Marfa, 22, X, 28, 2 ♂♂, 1 ♀. Chinati Mts., 16, IX, 29, 1 ♀; (7), 27, IX, 31, 2 ♀♀; 1 ♂, 2 ♀♀ (Univ. of Minn. Cln.) (common at altitudes of 5000 to 6000 ft.). Bunton Flat, 30 miles north Presidio, 29, VI, 30, 2 ♂♂, 5 ♀♀ (Hilaria mutica). Chisos Basin, 24, X, 46, 1 ♀. 7 miles south Van Horn, Texas, 30, X, 46, 1 ♀.

This small diminutive species, especially the male sex, is found frequently in tall grass on the northern slopes of the Chinatis at elevations from 5000 to 6000 feet. This species appears to belong to the Southwestern Grasslands fauna of the Upper Sonoran Zone but its range is largely undefined at present. Hebard, 1932, recorded it from Matamoras, Tamaulipas, Mexico.

† AMBLYTROPIDEA MYSTECA (Saussure)

Chinati Mts., (4), 4, V, 30, 1 ♂; 6, VI, 30, 3 ♂♂, 1 ♀; 8, VII, 30, 6 ♂♂, 5 ♀♀; 2 ♂♂ (Hebard Cln.), (all specimens collected in the same locality, a steep

narrow grassy declivity or cut at 5500 feet). Chinati Mts., (7), 27, IX, 31, 1 ♀ (about 5400 feet elev.).

A. auriventris McNeill, and *A. ingenita* Br., are synonyms.

This is the first Texas record and the first record east of Arizona for this very interesting and wary acridid. Its habitat was confined to one particular steep declivity extending as a narrow ravine down the steep north face of a high mountain plateau of the Chinati Mountains. This location was some five miles west of Shafter. The altitudinal range was about one hundred feet at the 5500 foot level, restricted to tall grasses in the bottom of the cut. The species was very elusive and difficult to capture. A special effort was made to secure this series and search over many miles of intervening territory failed to locate further specimens.

In this particular habitat *Rhammatocerus v. viatoria* was also taken for the first time east of Arizona along with the rare *Achurum sumichrasti*. These three belong to the Mexican Upper Sonoran fauna.

These records add much to our knowledge concerning the similarity of the fauna of the Big Bend Region as typified by the Chinati Mountains and perhaps the Chisos with those mountainous areas of south-central Arizona such as the Baboquivaris, Tumacacoris and the Santa Ritas.

The range of *A. mysteca* extends south from Arizona through Sonora into southern Mexico, a branch extending northeast from Sonora to the Big Bend Region.

Although *Amphitornus coloradus* McNeill has not been taken in the Big Bend Region it is believed that it may be found at higher elevations in the Davis Mountains.

ERITETTIX VARIABILIS Bruner

Chinati Mts., 6, VI, 30, 3 ♀♀; 1 ♀ (Univ. of Minn. Cln.). Marfa, 22, VI, 30, 1 ♂, 4 ♀♀. Bunton Flat, 28 miles north of Presidio, 29, VI, 30, 1 ♀ (in *Hilaria mutica*).

This appears to be one of the first records of this species from Trans-Pecos Texas. *E. variabilis* closely resembles *Amphitornus coloradus* in size and form, both possessing strongly receding faces and are of the same small size. However, *Eritettix* can be immediately differentiated by the long and unequal size of the inner calcariae of the caudal tibiae, those in *Amphitornus* being small.

E. variabilis is a member of the Southwestern Grasslands fauna of the Upper Sonoran Zone. Its range extends from the Big Bend Region to central Arizona on the Mogollon Plateau and north throughout New Mexico to Las Animas County in southern Colorado.

PHLIBOSTROMA QUADRIMACULATUM (Thomas)

Marfa, 22, X, 28, 2 ♀♀; 5, X, 29, 1 ♂, 1 ♀. Chinati Mts., elev. about 5500 ft., (7), 27, IX, 31, 1 ♂, 1 ♀. Davis Mts., 22, X, 28, 1 ♂, 1 ♀; 29, IX, 31, 1 ♀ (Univ of Minn. Cln.).

Synonyms: pictum and *parvum*.

This species is readily distinguished by its greenish body markings, relatively large head and with four crenulate markings on the tegmina giving it its name. It is a rare species in the Big Bend Region being found most often in the Davis Mountain Region, although it occurs on the adjacent Marfa Plains. I was surprised to find it on the north slopes of the Chinati at about 5500 feet elevation.

P. quadrimaculatum is a common species on the Great Plains east of the Rockies from the Canadian prairie provinces to southern Mexico and east to central Dakotas, Nebraska, Kansas and western Oklahoma and central Texas west to central Arizona. Although its distribution extends over practically all the Transition Zone this species is equally at home on the Upper Sonoran Grasslands. This is undoubtedly due to the wide range in its temperature life requirements. A study of its relative abundance in these zones would indicate the zone in which it is an endogene.

KEY TO THE SPECIES OF CORDILLACRIS REHN FROM THE BIG BEND REGION

1. Tegmina with usually five solid crenulate markings ..... *crenulata*
Tegmina usually with a dark central stripe broken up by lighter interspaces ..... *occipitalis*

CORDILLACRIS OCCIPITALIS OCCIPITALIS (Thomas)

Bunton Flat, 28 miles north of Presidio, 29, VI, 30, 1 ♂, 2 ♀♀ (*Hilaria mutica*). Marfa, 6 miles east, 29, VI, 30, 1 ♀ (sparse grass on stony soil).

C. apache is a synonym.

The Cordillacri are forms that appear in early summer and seldom if ever are taken in the late summer. This species is a member of the Southern Short Grasslands fauna of the Upper Sonoran and as such ranges north over the plains east of the Rockies and west of central Kansas and Nebraska to the southwestern corner of South Dakota and the southeastern corner of Montana. Here intergradation occurs with *C. occipitalis cinerea*, the northern race, that extends its distribution north to the Canadian prairie provinces. In the southwest *occipitalis* ranges west to southeastern Arizona. These appear to be the first records for southwestern Texas.

CORDILLACRIS CRENULATA CRENULATA Bruner

Marfa, 22, VI, 30, 3 ♂♂, 8 ♀♀ (common on prairie). 6 miles west and 6 miles east of Marfa, August 13, 1940, 3 ♂♂, 2 ♀♀.

This appears to be a record for southern Texas, the southernmost point previously having been Amarillo, Texas. The Marfa specimens mature in mid-June and are not uncommon on the prairies at that time.

This species ranges from southern Montana southward between the Rockies and the western sections of Nebraska and Kansas to the Panhandle of Texas. South of northern Texas its range is not known but its distribution undoubtedly follows the grasslands of New Mexico south to Trans-Pecos Texas and southeastern Arizona. This species is also a member of the Southern Short Grasslands fauna of the Upper Sonoran Zone.

ORPHULELLA PELIDNA DESERTA Scudder

Presidio, 6, VI, 30, 1 ♀; 1 ♂ (Univ. of Minn. Cln.).

Stenobothrus maculipennis Sc., *S. propinguus* Sc., and *Orphulella pratorum* Sc., are synonyms.

Gurney in his revision of the genus *Orphulella* Giglio-Tos, in 1940, has shown by his studies that *deserta* is the western race of the species. Its range extends from southeastern Alberta where it is very rare, south into Mexico and west to the eastern border of Arizona, and areas northwest.

The Presidio specimen was taken in Bermuda grass surrounding an ox-bow pond, near that town. This species appears to be a member of the Upper Sonoran fauna finding life conditions favorable only in the cultivated valleys of the Lower Sonoran Zone.

ACANTHERUS PIPERATUS Scudder

Chinati Mts., (1), 12, X, 29, 1 ♂; 29, IX, 29, 1 ♀.

This species is an extremely rare species in the Big Bend Region; only one pair having been encountered during two years of intensive collecting. According to Rehn and Hebard it is apparently more common in the Franklin Mountains just north of El Paso, but it finds its optimum life conditions in Arizona where it is known west to the Ajo Mountains and north to Yarnell Hill.

A. piperatus inhabits the upper limits of the Lower Sonoran and the lower edge of the Upper Sonoran and in Lower Sonoran environments in Arizona is especially adapted to life in the Sahuaro-Palo Verde-Encelia association. It ranges south into Sonora, Mexico and the Chinati Mountain records may prove to be the first for the Big Bend Region.

AGENEOTETTIX DEORUM DEORUM (Scudder)

Marfa, 5, X, 29, 2 ♀♀. Paisano, 29, VI, 30, 2 ♀♀. Chinati Mts., (7), 27, IX, 31, 1 ♂; 1 ♂, 3 ♀♀ (Univ. of Minn. Cln.). Davis Mts., Cox's Ranch, Jeff Davis Co. 29, IX, 31, 1 ♀ (south slopes of Mt. Livermore at 7000 feet). 6 miles east of Marfa, 13, VIII, 40, 2 ♂♂. 3 miles west of Shafter, 19, X, 46, 1 ♀ (rare).

A. scudderi Br., *A. occidentalis* Br., and *A. arenosus* Hancock, are synonyms.

This small darkish species with whitish antennae is a common species of the Great Plains. It ranges west of the Mississippi to the Rockies and from southern Alberta to northern Mexico, and from the Marfa grasslands west to southeastern Arizona. It also occurs in Utah.

A. deorum is a member of the Upper Sonoran Faunal Zone but it also ranges into the lower limits of the Transition Zone.

KEY TO THE SPECIES OF PSOLOESSA OF TRANS-PECOS TEXAS

1. Size small, form slender; lower half of lateral lobes of the pronotum light colored; mainly Lower and Upper Sonoran ..... *texana pusilla*

Size larger, form more robust; lateral lobes of pronotum not light and dark; mainly Upper Sonoran and Transitional ..... *d. delicatula*

PSOLOESSA TEXANA PUSILLA (Scudder) atypical

Chinati Mts., 16, IX, 29, 1 ♀; 4, V, 30, 3 ♀♀; 6, VI, 30, 1 ♀ (Univ. of Minn. Cln.). Elephant Rock, 28 miles north of Presidio, 22, VI, 30, 3 ♀♀; 29, VI,

30, 1 ♀. Bunton Flat, 29 miles north of Presidio, 29, VI, 30, 1 ♂, 2 ♀♀. Marfa, 22, VI, 30, 3 ♂♂, 5 ♀♀. Paisano, 28, VI, 29, 1 ♀.

Stirapleura mescalero Rehn, is a synonym.

Rehn (1942) in his admirable treatise has finally brought order to this plastic and difficult genus *Psoloessa,* and the enquiring student will do well to consult his work *On the Locust genus Psoloessa.*

Typical *P. t. pusilla* extends east of a line approximately drawn from Quitobaquito, Growler Valley, Plumosa Mts., Kingman, Ash Forks, ten miles east of Flagstaff, Tuba City and Fort Wingate, New Mexico, to the Tularosa Basin, Sierra Blanca and the Quitman Mountains. East of these latter points atypical *texana pusilla* exists. All specimens from the Davis Mountain region, the Marfa Plains and higher elevations in the Chinati and Chisos Mountains are atypical *pusilla.* Further east in the Uvalde, Carrizo Springs region transition to *texana texana* occurs.

P. t. pusilla is an inhabitant of the Upper Sonoran Grasslands with temperature requirements extending its range into the upper portion of the Lower Sonoran in desert grassland areas. It is, however, absent from the more xerothermic portions of the desert.

PSOLOESSA DELICATULA DELICATULA (Scudder)

Grasslands near head of Pinto Canyon, Chinati Mts., 7, VI, 30, 1 ♀ (elev. about 6000 feet). 6 miles west of Marfa, 13, VIII, 40, 2 ♂♂.

Synonyms: P.? coloradensis Thos., *P.? eurotiae* Br., *Stirapleura decussata* Scudder, and *S. tenuicarina* Sc.

Rehn (1942) designated a male collected by A. S. Packard, July 13, 1875, in the Garden of the Gods, in Colorado as the Lectotype.

The range of *delicatula* is extensive, extending from Aweme, Manitoba, Saskatoon, Saskatchewan and Calgary, Alberta, south to northern Durango, Mexico, and east of the Rockies to the central Dakotas, Nebraska, western Kansas and Oklahoma to Marathon in Trans-Pecos Texas, and west of the Big Bend to central Arizona where it is commonest on the Mogollon Plateau.

Delicatula is an early spring form that finds its optimum life conditions on the Great Plains of the Upper Sonoran and Transition Zones.

† RHAMMATOCERCUS VIATORIA VIATORIA (Saussure)

Chinati Mts., (4), 4, V, 30, 1 ♂ (elev. c. 5500 feet; tall grass on steep mtn. slope). Chinati Mts., (7), 27, IX, 31, 1 ♂ nymph.

Synonyms: nobilis (Walker), *patriae* (Sc.), *calida* (Br.), *macneilli* (Br.), while *excelsa* (Br.), and *viatoria cyanomera* Hebard, have only racial status.

Until the last few years this interesting large grasshopper has been known by the name of *Scyllina,* which name is now restricted to several closely related forms.

This is the first Texas record and the first record east of south central Arizona for this interesting genus and species. This large acridine resembles an extremely large *Psoloessa* or *Bruneria.* It is swift on the wing, flying considerable distances and then diving headlong into the tall grasses growing on the

steep mountain slopes that are its home. Figure 24 depicts the habitat where the first adult male was captured. It was also the same habitat for *Amblytropidea mysteca* (also taken for the first time east of Arizona) and for the rare *Achurum sumichrasti,* all three of which inhabit identical habitats in Arizona or elsewhere.

Viatoria is an early spring form as an exhaustive search in the same habitat in June and July failed to reveal further adults. One nymph was taken at about 5300 feet in late September, 1931. The nymphs mature in October and the adults are found from then on until May. The thirty-to-sixty eggs are laid in the spring and hatch with the rains in July or August.

Rhammatocerus viatoria is an inhabitant of the Mexican Upper Sonoran Zone and in Arizona and Sonora inhabits the Sonoran Live Oak belt of the Upper Sonoran Zone. This Live Oak belt is found from the Baboquivari Mts., east through the Tumacacori and Santa Rita Mts., Canillo Hills to the Huachucas, and north to the Santa Catalinas. From Arizona its distribution

Fig. 24.—Type of habitat for *Rhammatocerus v. viatoria, Amblytropidea mysteca* and *Achurum sumichrasti* on the steep northern slopes of the Chinati Mountains at about 5500 feet elevation. Cibolo Arroyo several miles above Shafter is shown in the valley.

extends south to Central America. A branch or side arm connects the Chinatis with oak areas in Sonora *via* central Coahuila as botanical explorations by Johnson and Mueller revealed in 1940.

BOOPEDON NUBILUM (Say)

Paisano, 8, X, 28, 1 ♂. Marfa, 22, X, 28, 2 ♀♀; 4, X, 29, 2 ♀♀; 5, X, 29, 2 ♀♀. Elephant Rock, 28 miles north of Presidio, 30, IX, 29, 1 ♂ (very rare in this locality). Lower Limpia Canyon, Jeff Davis Co., 4, X, 29, (common in tall grass although black females were rare). Chinati Mts., (7), 27, IX, 31, 2 ♂♂, 2 ♀♀. 8 miles east of Kent, Jeff Davis Co., 14, IX, 40, 3 ♂♂, 1 ♀. 3 miles east of Alpine, 22, X, 46, 3 ♂♂, 1 ♀.

Boopedon nubilum is a common species in the tall grasses of the Davis Mountain region. The females of this unique acridine are dimorphic, the brown females being the color phase commonly encountered; the black females similar in color to the males are rather rare. In this respect the females resemble the males of *Melanoplus differentialis* but the incidence of melanism is somewhat higher. The males of *B. nubilum* are shining jet black and constant in color.

B. nubilum ranges west from Trans-Pecos Texas to southeastern Arizona where it is known west to the Quinlan Mts. and north to the grasslands between the Galiuros and the Pinalenos. North of southwestern Texas it ranges east of the Rockies to Ft. Benton and Nashua, Montana and areas in North Dakota southwest of the Missouri River. Eastern limits are central Nebraska and Kansas, western Oklahoma and northern Texas.

This species is a member of the Southern Short Grasslands fauna of the Upper Sonoran Faunal Zone.

* ZAPATA BREVIPENNIS Bruner

Chinati Mts., 16, IX, 29, 1 ♂, 2 ♀♀; (7), 27, IX, 31, 2 ♂♂, 3 ♀♀, 2 ♀♀ (Hebard Cln.). Chinatis, 2 mi. s. of Shafter 18, X, 46, 3 ♂♂, 2 ♀♀.

These are the first North American records, north of Mexico, for this Mexican species which was based on a female from Lerdo, Durango. In 1927, Rehn described *Z. bucculenta* from a female from Durango, Durango, which species Hebard (1932) considered as probably a synonym of *brevipennis*.

Z. brevipennis has an altitudinal range of several hundreds of feet, approximately 4200 to 4500 feet, which represents the lower levels of the Chinati Mts. Its habitat appears to be short grass on stony hillsides covered with low scrubby clumps of *Acacia Roemeriana* and *Nolina texana* which afford good protection. This species has remarkable saltatorial powers, the diminutive males especially are exceedingly elusive and fully capable of jumping six to nine feet. The male is one of the smallest acridines found on the desert and is much smaller than the female sex. The large bulging head, small oval wing pads, reddish body color and coral pink caudal tibiae afford diacritical characters for the recognition of this species.

Z. brevipennis is known only from Durango, Mexico, and the Chinati Mountains of Presidio County, Texas. Hebard's 1932 record from the Chinatis was collected by the writer. This species is a member of the Mexican Lower

Sonoran fauna that finds its northernmost limits of distribution in the Chinatis and possibly the Chisos Mountains although search in October, 1946, failed to reveal it in those mountains. On the Sonoran Desert, *Zapata* is represented by the longer winged species *salutator* Rehn, which is found in the Sahuaro-Palo Verde-Encelia Zone of that desert.

†† HELIAULA RUFA (Scudder)

Marfa, (14), 29, VI, 30, 1 ♂ (specimen very dark). Chinati Mts., (7), 27, IX, 31, 1 ♀ (elev. c. 5000 feet). Six miles west of Marfa, 14, VIII, 40, 1 ♂, 1 ♀.

This is one of the rarer species of the Big Bend Region and these records constitute the first for Texas; the species not having been known previously southeast of the Organ Pipe Mountains in south-central New Mexico.

H. rufa was originally described as a species of *Aulocara* in the subfamily Acridinae, and then was removed to the Oedipodinae where the genus *Heliaula* was erected for it. There it has remained many years. The writer has removed it to a place near *Zapata* upon taxonomical features and the sculpturation of its egg. In the writer's study on the sculpturation of the eggs of Arizona range grasshoppers, the egg of *Heliaula* is only partly sculptured on the body of the egg and on the cap, which would place it after *Aulocara, Drepanopterna* and *Zapata* but ahead of *Morsiella* and *Boopedon.*

H. rufa is a member of the Southwestern Grasslands fauna of the Upper Sonoran Faunal Zone. Its range extends from the Big Bend Region west to the Cobabi Mountains of Arizona north to southern Utah, southwestern Colorado and east of the Rockies to Sidney, Nebraska, but it has not been reported from Kansas.

DREPANOPTERNA FEMORATUM (Scudder)

Marfa, 22, X, 28, 1 ♂, 4 ♀♀; 5, X, 29, 3 ♀♀; 29, VI, 30, 1 ♀. 15 miles south of Marathon, Brewster Co., 18, VII, 30, 1 ♀. Alpine, Brewster Co., 18, VII, 30, 1 ♀. Davis Mts., south base of Mt. Livermore, 29, IX, 31, 1 ♀; 1 ♀ (Univ. of Minn. Cln.). 10 miles north of Marfa, Presidio Co., 13, X, 46, 1 ♂. 6 miles northeast Ft. Davis, 12, X, 46, 2 ♂♂.

This species described as an *Aulocara,* in 1899, was placed in this monotypic genus by Rehn in 1927. From *Aulocara elliotti,* its nearest relative, it is recognized by its shorter tegmina, more contrasting coloration and sexual variation; the male of *femoratum* being much smaller than the female. The lateral lobes of the pronotum and the caudal femora are more strikingly banded than in the more uniformly gray *elliotti.*

D. femoratum is an inhabitant of the Upper Sonoran Faunal zone and as such its distribution extends from the Milk River Valley of southeastern Alberta (Tinkham 1939) to Durango, Mexico, and from southeastern Arizona to the Big Bend Region and east of the Rockies to southwestern North Dakota, the western portions of South Dakota, Nebraska and Kansas and northern Texas.

AULOCARA ELLIOTTI (Thomas)

Marfa, 22, X, 28, 1 ♂, 1 ♀; 29, VI, 30, 1 ♂, 2 ♀♀. Chinati Mts., (1), 8, VI,

30, 1 ♂ (dark colored specimen caught by an asilid *Promachus magnus* (Bellardi). 6 miles east of Marfa, 13, VIII, 40, 1 ♂.

Synonyms: caerulipes, decens, strangulatum and *parellelum.*

This important range grasshopper was not uncommon in the Davis Mountains and on the Marfa grasslands. It proved to be an interesting and unusual ectogene when a dark colored male was rescued from a large asilid fly that had killed it with its proboscis in the desert foothills of the Chinatis, several miles south of Shafter, in Lower Sonoran environment. Its acridid associates were such species as: *Pedioscirtetes maculipennis, Mermiria texana, Acantherus piperatus, Trimerotropis pallidipennis* and *pistrinaria, Schistocerca vaga, Melanoplus aridus, Agroecotettix modestus crypsidomus* and *Phaulotettix eurycercus*—indeed a strange complex to be associated with. Such finds would certainly indicate that in every species there is some inherent instinct or force to extend the limits of its domain. This specimen was eighty miles south of the grasslands which possess environmental conditions approaching its requirements but certainly not optimum conditions, as testified by its rarity on the Marfa Plains. These records appear to be the first in Trans-Pecos Texas.

A. elliotti is an inhabitant of the Transition and Upper Sonoran Faunal Zones. Its range extends from the Canadian prairie provinces south to the Panhandle of Texas and east of the Rockies to the central portions of the Dakotas, Nebraska, Kansas and western Oklahoma. In the Southwest the grasslands of New Mexico extend its range south into Mexico, southeast to the Marfa Plains and west and northwest to southeastern Arizona, Mogollon Plateau, Utah and portions of the Great Basin region.

GONIATRON PLANUM Bruner

Chinati Mts., (1), 30, IX, 28, 1 ♂, 2 ♀♀; 8, VII, 29, 1 ♂; 29, IX, 29, 2 ♂♂, 2 ♀♀; 18, X, 46, 2 ♂♂ (all on small patch of *Flourensia cernua.*) 1 mile north of Bunton Flat about 28 miles north Presidio, 22, X, 46, 1 ♂. 10 miles north of Marfa, Presidio Co., 13, X, 46, 1 ♂♂ (small community of *F. cernua*). 20 miles north Chisos Mts., Brewster Co., 18, VII, 30, 1 ♂. Sierra Blanca, Hudspeth Co., 19, IX, 31, 1 ♂. 7 miles east Sierra Blanca, 13, VIII, 40, 2 ♂♂, 1 ♀. 8 miles east of Kent, Jeff Davis Co., 14, IX, 40, 1 ♂. 8 miles east Van Horn, 23, X, 43, 2 ♂♂. Road Junction (highways 54 and 62, 180) about 10 miles south Guadalupe Peak, Culberson Co., 9, X, 46, 2 ♂♂. 6 miles north of Hachita, N. Mexico, 3, XI, 46, 3 ♂♂. 3 miles east of Animas, N. Mexico, 3, XI, 46, 3 ♂♂ (present westward limit of distribution).

This interesting thamnophilous speices is found wherever its host plant, *Flourensia cernua,* the southern blackbrush, occurs in co-dominant stands with creosote. In Presidio County it is very rare because there seems to be only three small communities of *Flourensia* in the county, namely, 10 miles north of Marfa, 1 mile north of Bunton Flat and the valley 2 miles south of Shafter. Further east in Brewster County, *Flourensia* is a codominant plant with creosote over wide areas south of Alpine and Marathon and north of the Santiago Mts. The principal stands of creosote and blackbrush, however, occupy the Pecos subdesert extending north of the Davis Range and west of the Pecos to Guadalupe Peak, Salt Bush and thence northwestward and southwestward into New Mexico. On November 3, 1946, in cold unfavorable weather the

writer found it inhabiting the *Larrea-Flourensia* arms of the Chihuahuan Desert extending into southwestern Arizona *via* the pass in the Peloncillo Mts., six miles west of Animas, New Mexico. On that date the writer traced it to three miles east of Animas, but earlier in the fall it should be found on the east side of the Chiricahuas in Arizona.

Fig. 25.—*Goniatron planum* male, the blackbrush grasshopper stridulating on a stem of its host plant, *Flourensia cernua*, the southern blackbrush. Taken on the desert a few miles south of Guadalupe Peak, Culbertson County, Texas.

G. planum is a member of the Ligurotettigi of which *Ligurotettix* is the only other member but unlike the latter in which sexual variation occurs, the sexes of *Goniatron* are closely similar in size. The fore margin of the tegmina in *Goniatron* is strongly convex due to the modification of the tegmina for stridulation. The costal margin possesses numerous diagonal cells in both genera but *Goniatron* is distinguished by the fact that the subcostal vein bisects the marginal cells.

G. planum is an elusive creature with a ventriloquistic type of stridulation that makes it difficult to locate. It is most quickly captured by being forced out of blackbrush, where it plays a sort of hide-and-seek game by encircling the stem as its would-be captor seeks a new angle of approach and always keeping the stem in betwixt so that it is barely visible to its captor yet it sees the slightest move made by its pursuer. In bright sunlight *G. planum* is inclined to hide in the foliage on top of its host plant. When cloudy or in the late fall it is often observed on the bare adobe soil, found where its host plant grows, perhaps to gain warmth from the soil or perhaps the females are seeking locations to lay their few eggs.

The song of *Goniatron* commences as a rapid *tk-tk-tk-tk-tk—schick* followed by *schicks* at 30 to 60 seconds interval. Usually after being disturbed by its would-be captor it produces a *shuck-a-shuck* which to its pursuer who has been haunting them rather than hunting them for half an hour without reward, as a sort of taunt or sneer as if they were laughing at his futile efforts to catch them. On the ground *Goniatron* makes an occasional *tk-tk-tk*. It is

not known whether the females stridulate but the similarity in the tegmen between male and female would suggest that perhaps they do answer the sounds made by the male.

Goniatron is an inhabitant of the Pecos subdesert region of the Great Chihuahuan Desert as typified by the two co-dominant plants, creosote and blackbrush, and it is found wherever good stands of its host plant, *Flourensia cernua*, the blackbrush occurs. Naturally it is rare or absent on the periphery of the range of its host plant, for there the host plant itself becomes so scattered that the grasshopper would find livelihood most difficult and precarious. The principal range of *Goniatron* extends from the north side of the Davis Mountains to the Texas-New Mexico line and from the Pecos River west to Animas, in southwestern New Mexico, where the writer, in 1946, trailed it to within 18 miles of the Arizona boundary. It also occurs in the *Larrea-Flourensia* dominated mesas of Brewster County, as already described, and its distribution extends southeastward into northeastern Mexico where the writer found it on the Coahuila Desert, 37 to 42 miles northeast of Saltillo, in mid-August of 1940.

OEDIPODINAE

The Oedipodinae or band-winged grasshoppers are the handsomest of the grasshoppers as practically all members have colored or banded wings. The commonest wing color is yellow, with red, orange, yellow green or blue and rose red and black outwardly bordered with yellow appearing in the order named; rose red and black being rarest. Only *Camnula* and *Dissosteira* are genera of economic importance and these often become very destructive. The Oedipodinae are especially at home in desert regions of the World. The Sonoran and Chihuahuan Deserts of the United States and Mexico have a great variety of interesting genera and species.

KEY TO THE GENERA OF THE OEDIPODINAE OF TRANS-PECOS TEXAS

1. Spines of the caudal tibiae more than 14; median carina of the pronotum very strongly cristate, arcuate like a comb with serrate margins; color greenish, wings orange ..... *Tropidolophus*

   Spines of caudal tibiae less than 12; color never green 2

2. Median carina of the pronotum distinct, cut by one or two sulci 3

   Median carina of the pronotum indistinct, lined usually by one sulcus 15

3. Median carina arcuately raised, cut shallowly or deeply by one sulcus 4

   Median carina low, cut by one or two sulci 5

5. Wings yellowish orange or red; median carina shallowly notched by the median sulcus ..... *Arphia* Stål

   Wings black narrowly margined with yellow; median carina cut deeply by one sulcus; size large ..... *Dissosteira* Scudder

5. Median carina cut distinctly by one sulcus 6

   Median carina cut distinctly by two sulci 9

6. Prozona longer than the metazona; principal sulcal depression caudad of center; vertex broadly and smoothly rounding into the face; caudal tibiae orange ..... *Hippiscus* Saussure

   Prozona not longer than the metazona; the sulcal depression central or cephalad of center 7

7. Caudal tibiae red; median carina distinctly raised ..... *Spharagemon* Scudder
Caudal tibiae blue or grayish; median carina low 8
8. Median carina low; fastigium rounding into the face; median sulcus distinctly impressed ..... *Platylactista* Hebard
Median carina more elevated, merely notched by the median sulcus; fastigium more angularly rounding into face ..... *Encoptolophus* Scudder
9. Size large and robust; prozonal carinal lobes indistinct, the principal sulcus notching the median carina so that the prozona and metazona are almost equal 10
Size medium and slender or small; median carina of the prozona usually distinct and bilobate, the principal sulcus cutting the median carina cephalad of center so that the metazona is distinctly longer than the prozona 11
10. Caudal tibiae bluish; wing disc bluish or yellowish green ..... *Leprus* Saussure
Caudal tibiae coral red; wing disc yellowish ..... *Xanthippus* Saussure
11. Posterior angle of the lateral lobes of the pronotum angularly produced into an acutely angled lobe 12
Posterior angle not produced into an acutely angled lobe but more or less squarely rounded 13
12. Median carina very low ..... *Rehnita* Hebard
Median carina high with the prozona distinctly bilobate ..... *Trachyrhachis* Scudder
13. Size small; prozona unilobate; metazona wrinkled or rugose ..... *Derotmema* Scudder
Size medium; prozonal crest bilobate; metazona smooth 14
14. Lateral lobes of the prozona with a diagonal black stripe; wings yellow orange or reddish orange ..... *Mestobregma* Scudder
Lateral lobes of pronotum immaculate; wings yellow, rarely bluish green ..... *Trimerotropis* Stål
15. Wings rose red ..... *Heliastus* Saussure
Wings azure ..... *Anconia* Scudder
Wings yellowish 16
16. Antennae very long and heavy; prozona much shorter than the metazona; tegmina trifasciate or three-banded; caudal tibiae red; size large. Grasslands ..... *Hadrotettix* Scudder
Antennae finely filiform; prozona about equal to the metazona; wings pale citron; caudal tibiae bluish white; size medium; gravel areas ..... *Cibolacris* Hebard

KEY TO THE SPECIES OF ARPHIA OF TRANS-PECOS TEXAS

Body color black; wings deep red; caudal tibiae blackish ..... *crassa*
Body color greyish to whitish grey, wings orange; caudal tibiae greenish ..... *aberrans*

ARPHIA CRASSA Bruner

Davis Mts., 22, X, 28 (a very common species in the grasslands ranging from 5000-6000 feet elevation), Marfa, 5, X, 29 (fairly common). Chinati Mts., (7), 27, IX, 31, 1 ♀; 1 ♂ (Univ. of Minn. Cln.). Davis Mts., south slope of Mt. Livermore, Cox's Ranch, 29, IX, 31, 1 ♀, (Univ. of Minn. Cln.). 6 mi. East of Kent, 23, X, 43, 1 ♂. Chisos Basin, 24, X, 46, 1 ♂, 1 ♀. Top of Green Gulch, Chisos Mts., 23, X, 46, 1 ♀.

This species was found not uncommonly in the tall grass on the gentle sloping base approaching Blue Mountain, at from 5000 to 6000 feet elevation in the Chinatis. Its distinctive black colored body and beautiful deep red wings cutwardly banded with black serves to distinguish this species from any other in the region. In this habitat it was associated with *Hippiscus rugosus* and *Leprus wheeleri*.

In the Davis Range it was very abundant in the fall of 1928 and large swarms with their showy wings flew up from the tall grasses. It was there associated with *Trimerotropis melanoptera* and other species such as *Drepanopterna femoratum* and *Melanoplus* spp.

Superficially resembling *A. pseudonietana* it is distinguished by its more robust appearance and the semi-tectate plane of the pronotum.

A. crassa is an endogene of the Southwestern Grasslands fauna of the Upper Sonoran and inhabits the mountain grasslands and the adjacent plains, from Trans-Pecos Texas throughout southern New Mexico to southeastern Arizona. Its northern limits are undefined and although occurring in northern Mexico it has not been recorded; it is here recorded from northern Sonora for the first time.

ARPHIA ABERRANS Bruner

Twenty miles south of Marfa, 27, IX, 29, 1 ♂. Chinati Mts., 16, VI, 29, 4 ♂♂, 3 ♀♀; 1, VI, 30, 1 ♀; 4, V, 30, 5 ♂♂, 3 ♀♀. Chinati Mts., 16, VI, 29, 2 ♂♂, 3 ♀♀ and 6, VI, 30, 1 ♂ (Univ. of Minn. Cln.). Wilson's Ranch, west base of Mt. Emory, Chisos Mts., Brewster Co., 17, VII, 30, 1 ♀ (Hebard Cln.). San Carlos Silver Mines, 10 miles southwest of San Carlos, Chihuahua, Mexico, 31, V, 30 (common on the mountain sides at 6000 ft. elevation).

This species is an early spring form that is found most commonly on the limestone outcrops in the desert mountains where its adaptive coloration serves to render it inconspicuous.

A. aberrans is an inhabitant of the Lower and Upper Sonoran Zones. Its range is at present undefined but it appears that its distribution is similar to that of *A. crassa* ranging from Trans-Pecos Texas to southeastern Arizona (in the mountains) and occupying the southern portions of New Mexico. The San Carlos specimens are the first Mexican records. The type specimen was described from a single female taken in the Huachuca Mountains in southeastern Arizona.

ENCOPTOLOPHUS SUBGRACILIS Caudell

Presidio, 15, VI, 30, 1 ♀. Ochoa, 23, X, 28 (common in Bermuda grass along irrigation ditches). The following specimens are in the Univ. of Minn. Cln.: Brownesville, (F. S. Snow) 1 ♂. Tucson, Ariz., 1 ♀. El Paso, Texas, 1 specimen. Lower Limpia Canyon, 20 miles southwest Balmorhea, 12, X, 46, 1 ♂, 2 ♀♀.

E. texensis Bruner was established as a synonym by Hebard in 1925.

This species was fairly common in certain localities where Bermuda grass grew abundantly along irrigation ditches in the cotton fields; otherwise it was met with rarely.

E. subgracilis belongs to the Lower Sonoran fauna and its distribution ranges from Houston, Texas, to the Salt River and Yuma valleys of Arizona. It occurs in Kansas and southeastern South Dakota but it has not been taken in Nebraska, Colorado or Oklahoma.

Hebard (1925-32) records it from the following states in Mexico: Sinaloa, Durango, Nuevo Leon, Tamaulipas, Vera Cruz, Guanajuato, Queretaro and Jalisco.

XANTHIPPUS CORALLIPES PANTHERINUS Scudder

Paisano, 28, VI, 29, 1 ♂, 2 ♀♀. Marfa, 4, VI, 30, 1 ♂, 3 ♀♀ (street lights). Presidio, 15, V, 30, 2 ♂♂, 3 ♀♀ (at lights). Grasslands near the head of Pinto Canyon, Chinati Mts., 7, VI, 30, 1 ♂, 1 ♀ (elev. about 5800 feet). Presidio, 15, VI, 30, 1 ♀; 25, V, 30, 2 ♀♀ (Univ. of Minn. Cln.). Eastland Co., Texas, 11, V, 21 (Grace O. Wiley), 1 ♂, (Univ. of Minn. Cln.).

This speices is an early summer form that is quite common on the grasslands of the Big Bend Region. It is easily recognized by its large robust size, yellow wings, maculate tegmina and the rugose pronotum. The caudal tibiae are coral red and the internal face of the caudal femora is bluish black which serves to distinguish it from the Arizona race *corallipes corallipes*.

Until recently, considerable confusion existed in the literature as to the validity of the many species placed in the old genus *Hippiscus*, but Hebard, 1928 to 1932, has dealt in detail with the problem, made the proper generic assignments and placed many names in synonymy. At the present time five main races are recognized, namely: *latefasciata* of the northern and *pantherinus* of the southern great plains, *buckelli* of the northern portions of the Great Basin and *corallipes* and *leprosus* of the Southwest.

Those of concern here are *latefasciata* ranging from the southern portion of the three Canadian prairie provinces south to Colorado and east of the Rockies to western South Dakota, Nebraska and the northwestern corner of Kansas. In the west-central Kansas and southeastern Colorado *latefasciata* grades into the southern race *pantherinus*. This race occupies the southwestern third of Kansas, western Oklahoma, south to College Station and San Antonio, Texas, thence west to New Mexico where it merges into *corallipes corallipes*.

HIPPISCUS RUGOSUS (Scudder)

Daxis Mts., (20) Perkins Ranch, Jeff Davis Co., 6, X, 29, 3 ♀♀ (under live oaks at about 6500 feet elev.). Chinati Mts., (7), 27, IX, 31, 6 ♂♂, 4 ♀♀; 2 ♂♂, 2 ♀♀, Hebard Cln.); 2 ♂♂ (Univ. of Minn. Cln.), (tall grass on open hillside at about 5300 feet). Ft. Davis, Tex., 13, X, 46, 4 ♂♂, 5 ♀♀. Lower Limpia Canyon, 6 mi. NE. Ft. Davis, 12, X, 46, 3 ♀♀.

This species has a most unusual distribution. Its northern boundary runs from southeastern Montana, southwestern North Dakota (new record), Illinois, Indiana to Maine. South it occurs to northern Florida, Alabama, Oklahoma to Amarillo, Texas. It has not been taken in New Mexico, only sparingly in Colorado and Amarillo marked its previous known southern limit in Texas.

It is indeed surprising to discover this species in southwestern Texas at a point many hundreds of miles south of any previous record, and this constitutes the southern limit of distribution in the United States. Undoubtedly it will be found in eastern New Mexico. Another interesting feature of its discovery is that fact that it occurred in two contrasting habitats. In the Davis Mountains, in 1929, a few specimens were found under oak trees in oak-sylvan environment which represents its normal habitat. As no thorough collecting was then done it was possibly more abundant than the records would indicate. In this habitat it was associated with *Spharagemon bolli inornatum*.

No specimens were discovered on the southern slopes of Mt. Livermore although it was diligently searched for in 1931.

The other habitat was located on the gently sloping grasslands near the base of Blue Mounain in the Chinati Range. There at altitudes ranging from about 5000 to 5600 feet it was fairly common in the tall grasses associated with *Arphia crassa, Leprus wheeleri,* and an occasional *Boopedon nubilum, Hadrotettix trifasciatus, Opeia imperfecta* and others.

Hippiscus rugosus is a member of the Upper Sonoran fauna but unlike most other species seems to be able to tolerate the humid east as well as the arid southwest. Hence its range covers the Upper Sonoran east of the Rockies and the humid Carolinian subsection of the Upper Sonoran. Recently it has been found in oak-savannah type of habitat in southern Arizona and in northern Sonora, Mexico, just south of Nogales; these representing new records.

KEY TO THE SPECIES OF LEPRUS OF TRANS-PECOS TEXAS

Wing disc greenish yellow; caudal tibiae glaucous ..... *wheeleri*
Wing disc bluish green; caudal tibiae and thoracic and abdominal sternites suffused with deep bluish ..... *cyaneus*

LEPRUS CYANEUS Cockerell

Paisano, 29, VI, 29, 2 ♂♂. Davis Mts., Lower Olympia canyon, 4, X, 29, 2 ♂♂ (tall grass on hillsides at about 5000 feet). Chinati Mts., (3), 16, IX, 29, 3 ♀♀; 23, IX, 29, 1 ♀ (tall grass in small canyon at about 5000 foot elev.). Wilson's Ranch, west base of Mt. Emory, Chisos Mts., Brewster Co., 17, VII, 30, 3 ♂♂, 2 ♀♀ Hebard Cln.; elev. about 5800 ft.). Chinati Mts., 27, IX, 31, 2 ♂♂. Davis Mts., south base of Mt. Livermore, Cox's Ranch, 29, IX, 31 (Univ. of Minn. Cln.; elev. about 6000 ft.). 3 miles west of Shafter, 19, X, 46, 1 ♂. 6 miles northeast of Ft. Davis in Lower Limpia canyon, 12, X, 46, 1 ♀. 20 miles southwest Balmorhea near mouth of Lower Limpia canyon, 12, X, 46, 1 ♀. 3 miles east of Alpine, Brewster Co., 22, X, 2 ♀♀. Pass top of Green Gulch en route Chisos Basin, 23, X, 46, 3 ♂♂, 2 ♀♀. South base Pulliam Bluff, Chisos Basin, 24, X, 46, 2 ♀♀.

Hubbell in 1925 recorded this species from Phantom Lake, Jeff Davis Co., 8, VIII, 1916 (F. M. Gaige), 1 ♂, and Organ Mts., Dona Ana Co., New Mexico, (W. A. Archer) 5, IX, 24, 3 ♀♀.

The *type locality* of the species is Raton, New Mexico.

Cyaneus is readily separated from *wheeleri* by the deep blue suffusations on the thorax and abdomen and the bluish green wings. It is found in the mountains whereas *wheeleri* is a species of the plains; *cyaneus* is seldom found below 5000 feet elevation, being commonest at about 6000 feet.

Revision is badly needed in this genus and until that has been accomplished the range of *cyaneus, wheeleri, interior, glaucipennis* and *robustus* will remain uncertain.

At present *cyaneus* has a restricted range from the mountains of the Big Bend Region to the southern border of Colorado and west in New Mexico to east central Arizona (Springerville area) and occasionally in the mountains of southeastern Arizona. In respect to its distribution *cyaneus* appears to fall into a small group of species such as *Leprus wheeleri, Spharagemon inornatum, Rehnita capito,* and *Trimerotropis melanoptera* all of which appear to have a similar though largely undefined range.

LEPRUS WHEELERI (Thomas)

Presidio, 21, IX, 28, 1 ♂ (at light). Davis Mts., 22, X, 28, 1 ♂, 1 ♀. Presidio, 24, VIII, - 4, IX, 29, 4 ♂♂, 5 ♀♀ (all taken at light). Davis Mts., Lower Olympia Canyon, 4, X, 29, 2 ♂♂, Chinati Mts., (7), 27, IX, 31, 1 ♂, 5 ♀♀; 1 ♂, 2 ♀♀ (Univ. of Minn. Cln.). 6 mil. East of Kent, 23, X, 43, 2 ♂♂, 1 ♀.

This species is much more abundant than *cyaneus* and in the grasslands up to 5000 feet elevation in the Chinati Mountains it is a common species. It occurred on the sandy adobe flat adjoining the Cibolo Arroyo at Presidio but was not encountered elsewhere in the Valley. However, it came quite commonly to light in late August and early September when it was easily captured.

It appears that this species is mainly Upper Sonoran but may range into the Lower Sonoran Zone. Revision of the genus will be necessary to establish the boundaries of its range. At present it is known from eastern New Mexico and the Big Bend Region of Texas, but its distribution is undoubtedly more extensive than known at present.

TROPIDOLOPHUS FORMOSUS (Say)

Ft. Davis, 22, X, 28, 1 ♂. Chinati Mts., (3), 16, IX, 29, 2 ♂♂ (rare on hillsides at about 5000 feet elev.). Near Elephant Rock, 4, X, 29, 1 ♂ (short grasslands). Upper Olympia Canyon, Davis Mts., (18), 6, X, 29, 5 ♂♂, 2 ♀♀, (short grasses on hillsides at about 6000 feet elev.). Marfa, 29, VI, 30, 1 ♂, 1 ♀. Chinati Mts., (7), 27, IX, 31, 4 ♂♂; 2 ♂♂ (Univ. of Minn. Cln.). 6 miles east of Kent, 23, X, 43, 1 ♀. 8 miles east Van Horn, Texas, 23, X, 43, 1 ♂. Continental Divide, 40 miles west of Deming, New Mexico, 22, X, 43, 8 ♂♂. Mouth Lower Limpia Canyon, 15 miles southwest of Balmorhea, Jeff Davis Co., 12, X, 46, 1 ♂. 10 miles north of Marfa, Presidio Co., 13, X, 46, 6 ♂♂, 3 ♀♀ (feeding on Malva by road side; one female ovipositing). 9 miles east of Marfa, 29, X, 46, 3 ♂♂. 7 miles south of Van Horn, 30, X, 46, 1 ♂, 1 ♀.

This remarkable oedipodine by its unique appearance cannot be mistaken for any other Nearctic species. It is the only oedipodine that has more than 12 tibial spines and in this respect shows some resemblance to certain acridine genera such as *Acrolophitus* and *Syrbula* but differs strikingly in the form of the fastigium. Time may show that *Tropidolophus* is an important connecting link between the Acridinae and the Oedipodinae by being the offshoot from which one subfamily sprang from the other; the Oedipodinae from the Acridinae or *vice versa*. It is a fairly common species in the Davis Range especially in the sparse grass on certain rocky hillsides where it feeds on various species of *Malva*.

As a member of the Southwestern Grasslands fauna of the Upper Sonoran it ranges from the grasslands of the Big Bend to those of southeastern Arizona as far as the east base of the Galiuro Mts. North it occurs as far as Greeley, Colorado and the southwestern border of Kansas. Hebard has recorded *formosus* from Casa Grandes and Jiminez in Chihuahua, and Mazatlan, Sinaloa, Mexico.

PLATYLACTISTA AZTECUS (Saussure)

Ochoa, 23, X, 28, 1 ♂ (Bermuda grass). Davis Mts., 5, X, 39, 1 ♂. Marfa, 5, X, 29, 1 ♂, 2 ♀♀. Elephant Rock, 22, VI, 30, 2 ♂♂, 2 ♀♀. Chinati Mts., 27, IX, 31, 1 ♀; 1 ♂ (Univ. of Minn. Cln.). Mt. Newell, San Antonio, Tex., June, 1885.

1 ♂, 1 ♀ (Univ. of Minn. Cln.). 7 miles S. Van Horn, 30, X, 46, 2 ♂♂, 1 ♀, 1 mi. N. Persimmon Gap, Brewster Co., 23, X, 46, 2 ♂♂, 1 ♀. Chisos Basin, 24, X, 46, 1 ♀.

This species until very recently was known in the literature as *Tomonotus aztecus* Saussure. In 1932b, Hebard studied the *Lactista-Tomonotus* complex which was known to be an unnatural grouping and assigned *aztecus* to his new genus *Platylactista* and making *ferruginosus* Bruner, the type of the genus *Tomonotus* Saussure. *Platylactista, Lactista* and another new genus *Leurono-tma* are placed in the group *Lactistae; Tomonotus* representing the distinct group, the *Tomonotae*. Thus *Platylactista* is most closely allied to *Lactista* which is found in southwestern Arizona and southern California. *Tomonotus* dwells in the mountains of southcentral Arizona and northern Sonora in oak-sylvan environment, while *Leurotina* is a Mexican genus.

P. aztecus is found occasionally on the gravelly desert pavement where a sparse coverage of grass exists. In the Rio Grande Valley it was found on Bermuda grass along the irrigation ditches which certainly does not represent its normal habitat.

This species has a wide distribution in the desert regions of the Southwest. It is common in southeastern Arizona where the representatives are rust colored like the rocks or grayer to match the sands and gravel of the arroyos. In Mexico, Hebard has recorded it from Aguacalientes, Aguacalientes, and Saussures type came from Lake Metztillan, Hidalgo, Mexico. It also occurs in the state of Sonora but has not been previously recorded from there.

KEY TO THE SPECIES OF DISSOSTEIRA SCUDDER OF TRANS-PECOS TEXAS

Wing disc opaque black bordered with a narrow buff marginal band; color uniform varying from dark grayish to rust red and whitish ..... *carolina*

Wing disc not opaque black and with the marginal band broader and paler; tegmina more distinctly banded; a large and powerful flying species ..... *longipennis*

DISSOSTEIRA CAROLINA (Linnaeus)

Presidio, 16, VII, 29, 1 ♂ (Scout Paul Lujan).

The mystery of this record will never be solved. The specimen was taken in the town's main drugstore window where it undoubtedly was trapped after being lured to the bright store lights the previous night. The species may have been breeding in the valley due to changed agricultural conditions but no other specimen was seen throughout the entire region during two years of intensive collecting. What distances it had flown will never be known.

This is a very unusual record for *carolina,* for although it enjoys an extremely wide distribution in North America, it is an endogene of the Transitional Faunal Zone. It has never before been taken south of Quanah, in northern Texas, until this capture was made. In New Mexico the southernmost record was Albuquerque although the writer found this species fairly common in the Magdalena Mountains, west of Socorro, in the Transitional Zone, July 1930; yet this point is still some 500 to 600 miles distant from Presidio. Furthermore Presidio is typically Lower Sonoran.

D. carolina in the north ranges from the southern part of the Canadian

prairie provinces to Ontario and Maine; in the south from northern Florida to Oklahoma and northern Texas. West of the Rockies it is found from southern British Columbia to the Mogollon Plateau of Arizona.

DISSOSTEIRA LONGIPENNIS (Thomas)

Marfa, 5, X, 29, 2 ♀♀; 22, VI, 30, 2 ♀♀ seen. Ten miles west Marfa, 13, VIII, 40, 1 ♀.

This large species, not at all common on the Marfa grasslands, seems to prefer enclosed areas protected from grazing where the grass reaches its natural development. It is a powerful flyer and more often seen than captured.

D. longipennis is a member of the Southern Short Grasslands fauna of the Upper Sonoran and its range extends from south central South Dakota to northwestern Texas, and west of central Nebraska and Kansas to the plains of Colorado and northern New Mexico. As with *D. carolina* the Marfa records are a considerable extension southward of the known range of this species and hence are the first from southwestern Texas. There seems to be no doubt that when collections have been made more thoroughly over larger areas, it will be found that the grasslands of eastern New Mexico carry the range of many northern species south to the Big Bend Region.

Within the last four or five years *D. longipennis* has become a very important economic species in the Panhandle of Texas, northeastern New Mexico and southeastern Colorado and severe losses and large sums of money have been spent in an endeavor to control this handsome but very injurious species.

KEY TO THE SPECIES OF SPHARAGEMON OF TRANS-PECOS TEXAS

Pronotal crest very strongly carinate and deeply cut by the principal sulcus; coloration dark grayish. Habitat-sand environment ..... *cristatum*

Pronotal crest not strongly cristate and with the plane of the pronotum semi-tectate; coloration yellowish-brown; habitat; oak-sylvan environment ..... *inornatum*

SPHARAGEMON BOLLI INORNATUM Morse

Davis Mts., (20), 5, X, 29, 2 ♂♂, 4 ♀♀ (under live oaks in dry stream bed; elev. about 6500 ft.). Top of Blue Mt., Chinati Mts., 27, IX, 31, 1 ♂, 2 ♀♀ (tall grass with scattered trees at about 6700 feet); 1 ♀ (Hebard Cln.). North base of Blue Mt., 27, IX, 31, 1 ♀ (under oaks in arroyo bed at about 5400 feet elev.). South base of Mt. Livermore, Davis Mts., 29, IX, 31, 1 ♂, 5 ♀♀ (oak-sylvan location at elev. 6000-7000 feet); 2 ♀♀ (Hebard Cln.). Green Gulch, Chisos Mts., 23, X, 46, 1 ♀ (under oaks). Pass top Green Gulch en route Chisos Basin, 23, X, 46, 3 ♂♂, 5 ♀♀ (elev. c. 6500 ft.). South base of Pulliam Bluff, Chisos Basin, 24, X, 46, 1 ♀ (rare under oaks at 6500 ft.).

In the Davis Mountains this species was found only at considerable elevations in an oak-sylvan environment where its buff brown coloration matched perfectly with the fallen oak leaves that it was resting upon. At collecting locality (20) *Hippiscus rugosus* was found associated with it. On the table-like top of Blue Mountain in the Chinati Range the species was semi-sylvan and confined more to the grassy areas between the trees. In such environment it was associated with *Trachyrhachis aspera* which was taken for the first time in the Chinatis.

S. inornatum is an endogene of the Southwestern Mountain Transitional fauna and has a limited distribution. Hubbell, in 1925, recorded it for the first time from Texas in a female taken in Cherry Canyon on the north side of the Davis Range. It is now known from the southern border of Colorado, the mountainous region of northern New Mexico and the Davis, Chinati and Chisos Mountains of Trans-Pecos Texas.

SPHARAGEMON COLLARE CRISTATUM Scudder

Presidio, 20, X, 28, 1 ♂ (sandy areas); 29, X, 28, 1 ♂; 29, VIII, 29, 1 ♂ (at light). Marfa, 5, X, 29, 1 ♂. Presidio, 24, V, 30, 1 ♀; 15, VI, 30, 1 ♂, 1 ♀ (sandy areas).

These two species of *Spharagemon* are easily confused but can be separated by the following characteristics: *inornatum* dwelling in oak-sylvan environment belongs to the Transitional Zone whereas *cristatum* is arenicolous and pertains to the Lower Sonoran Faunal Zone; furthermore the strongly cristate and deeply sulcate pronotal crest, more slender form and darker coloration will serve to distinguish it from the more robust, shade-loving and buff-colored *inornatum*. In sandy areas in the Rio Grande Valley *cristatum* was associated with *Trimerotropis citrina*.

S. collare cristatum, if it deserves racial distinction, is the southern development of the more northern *S. collare collare* which has a very wide distribution from the Canadian prairie provinces south to Kansas and east of the Rockies to Maine and Florida. *Collare* is strongly influenced by environmental factors and many synonyms now exist for these forms. Whether *cristatum* will be retained as a race is a question whose solution will require much material from the Southwest. At present *cristatum* material ranges from southeastern Colorado and northern Texas to Monterey, Nuevo Leon and Valles, San Luis Potosi, Mexico.

KEY TO THE SPECIES OF TRACHYRHACHIS OF TRANS-PECOS TEXAS

Form slender; head not large for the size; wing disc chrome yellow; caudal tibiae bluish and caudal femora normal in lateral outline ..... *fuscifrons*

Form more robust with the pronotum rugose; head very large for the size giving it a megacephalic appearance; wing disc transparent; lateral margins of the proximal half of the caudal femora flanged or strongly keeled ..... *aspera*

TRACHYRHACHIS KIOWA FUSCIFRONS (Stål)

Marfa, 22, X, 28, 1 ♂; 4, X, 29, 1 ♀; 4, X, 29, 4 ♂♂, 4 ♀♀.

This species is not abundant on the Marfa grasslands.

Fuscifrons is the southern race of *T. kiowa kiowa* (Thomas) which has an extensive distribution east of the Rockies, from southern Alberta to northern Texas and east to southwestern Minnesota, Iowa and Oklahoma. On the southeastern periphery of its range it intergrades into the race *thomasi* and in the territory of northern Texas and southwestern Oklahoma into *fuscifrons*. The range of *fuscifrons* is as yet largely undefined. In 1932, Hebard recorded it from various localities in Mexico as: Tamaulipas, Nuevo Leon and San Luis Potosi.

TRACHYRHACHIS ASPERA Scudder

Alpine, 8, X, 28, 1 ♀. Davis Mts., 5-6, X, 29, 4 ♀♀. Marfa, 5, X, 29, 1 ♀. Top of Blue Mt. Chinati Mts., 27, IX, 31, 3 ♀♀ (tall grass; elev. 6700 feet); 2 ♂♂, 1 ♀ (Univ. of Minn. Cln.). South base of Mt. Livermore, Cox's Ranch, Davis Mts., 29, IX, 31, 2 ♂♂, 1 ♀; 1 ♂, 1 ♀ (Univ. of Minn. Cln.). Maguire Ranch, Upper Olympia Canyon, Davis Mts., Aug. 29-30, 1912, 1 ♀, (Rehn and Hebard; elev. 5000-5500 feet).

Bruner's *T. compacta* is a synonym.

This species is fairly common in the Davis Range and is easily recognized by its robust appearance, large head and strongly flanged proximal margins of the caudal femora. In the Chinati Mountains it was encountered only on the second highest peak of that range, Blue Mountain, and at the considerable altitude of 6700 feet.

T. aspera belongs to the South western Mountain Transitional fauna but its range is only meagerly known at present. Hebard (1929) gives its range as extending from Pine Bluffs, Wyoming, south through Colorado to the Sacramento Mountains of New Mexico and the Davis Mountains of Trans-Pecos Texas. To this range the Chinati Mountains are alone added as new. It is probable that *aspera* will be found at high elevations in the Chisos Range of southern Brewster County.

REHNITA CAPITO (Stål)

Chinati Mts., 9, IX, 29, 3 ♂♂, 2 ♀♀. Presidio, 24, VIII, 29, 1 ♂, 4 ♀♀ (at light). Chinati Mts., (7), 27, IX, 31, 2 ♂♂, 2 ♀♀; 3 ♀♀ (Univ. of Minn. Cln.); 19, X, 46, 1 ♀. North edge Davis Mts., Jeff Davis co. line, 12, X, 46, 1 ♀. 3 miles east of Alpine, 22, X, 46, 1 ♂.

Scudder's *Conozoa melleola* from the Organ Mountains in New Mexico is a synonym.

Hebard, in 1935, placed *Mestobregma capito* and *gracilipes* from Arizona in his new genus *Rehnita*. This genus as now recognized is much more slenderly constructed than *Mestobregma* as based on the genotype *plattei*.

This rare and graceful hopper was taken at about 5000 feet on gently sloping hill tops in the Chinati Mountains. I have never collected it in or around Persidio, so one wonders from what distances this species flew in to appear at the Presidio lights at night. There may be a possibility of night flying activity in the Acrididae in the southwestern desert regions especially when the temperatures range above 85 degrees Fahrenheit. Such temperatures up to 90 degrees are common evening temperatures during the summer months at Presidio.

The distribution of this species is inadequately known but seems to extend from the mountainous regions of Trans-Pecos Texas north through New Mexico to Canon City, Colorado.

KEY TO THE SPECIES OF MESTOBREGMA OF TRANS-PECOS TEXAS

Wing disc blood red in color; body color clayish white; caudal tibiae greyish white ..... *terricolor*

Wing disc yellowish outwardly edged by a narrow band; tegminal bands dark and well defined on the costal margin with the interspace buff ..... *corrugatum*

MESTOBREGMA PLATTEI CORRUGATUM (Scudder)

Paisano, 23, VI, 29, 1 ♂; 29, VI, 29, 3 ♀♀. Davis Mts., Upper Olympia Canyon, 6, X, 29, 1 ♀. South slope of Mt. Livermore, Cox's Ranch, Davis Mts., 29, IX, 31, 2 ♂♂, 1 ♀ (elev. about 5000 feet). Wilson's Ranch, West base of Mt. Emory, Chisos Mts., Brewster Co., 17, VII, 30, 1 ♂, 3 ♀♀ (elev. about 5000 feet). Pine Springs, New Mexico-Texas line, northeast of Guadalupe Peak, 19, VII, 30, 2 ♂♂, 2 ♀♀ (Hebard Cln.). Pass top of Green Gulch en route Chisos Basin, 23, X, 46, 2 ♂♂, 1 ♀ (elev. 6500').

Conozoa picturata Scudder, described from the Organ Mountains of southern New Mexico, is a synonym.

This species is at home in tall sparse grass on rocky hillsides and hilltops at from 5000 to 6000 feet elevation. In 1919 Rehn delineated *M. plattei* into three races: *plattei plattei* (Thomas) the Great Plains race ranging from Montana and southwestern North Dakota south to southern Colorado; *plattei corrugatum* (Sc.) a southern race extending from northern New Mexico southward; and *plattei rubripenne* (Bruner) of central and southern Arizona.

Corrugatum is widely distributed throughout the mountainous regions of New Mexico and Trans-Pecos Texas but is as yet unrecorded from Mexico although undoubtedly present in Chihuahua.

MESTOBREGMA TERRICOLOR Rehn

Chupadero Hills, 8 miles northeast of Presidio, 8, VI, 29, 1 ♀, (Scout Paul Lujan).

This very rare oedipodine was taken in the adobe hill region which appear to be its native habitat; its clay coloration blending perfectly with its terricolous nature and its blood red wings serving to separate this species from any other acridid of the region.

Rehn, in 1919, described this interesting species from Pecos, Texas, the type locality. It is more closely related to *Mestobregma impexum* Rehn, of the Great Basin area than to *plattei*, but it also exhibits tendencies towards the genus *Trepidulus* of Arizona.

M. terricolor is an endogene of the Lower Sonoran and has been taken at Pecos, Sierra Blanca and Presidio in Texas; Las Cruces in New Mexico and the Grand Canyon and southeastern Arizona. It is confined to areas of bare adobe soil and is extremely local in distribution. It has not been taken in Mexico.

DEROTMEMA HAYDENII MESEMBRINUM Rehn

Marfa, 4-5, X, 29, 3 ♂♂, 8 ♀♀, Presidio, 15, VI, 30, 4 ♂♂, 3 ♀♀ (adobe flat). Marfa, 22, VI, 30, 1 ♀. Bunton Flat, 28 miles N. Presidio, 22, VI, 30, 2 ♀♀. Marfa, 22, VI, 30, 1 ♂♂ (Univ. of Minn. Cln.). 7 miles S. Van Horn, 30, X, 46, 1 ♀. 1 mile N. Persimmon Gap, Brewster Co., 23, X, 46, 1 ♂.

This species was found to be quite abundant on bare adobe patches on the Marfa prairies. At Presidio it was taken only on an adobe flat with clumps of mesquite scattered about. The Presidio specimens were typical of the race whereas the Marfa ones were slightly atypical and portrayed a divergence towards the northern race *D. haydenii haydenii* (Thomas).

Rehn, in 1919, described *mesembrinum* as the southern race of the more northern *Derotmema haydenii haydenii* which has a wide distribution on the Great Plains. Double Windmill, in Brewster County, is the type locality and Marfa, the allotype locality. In addition the species has been taken in numerous places in Trans-Pecos Texas as well as in the following Mexican states: Coahuila, Durango and Zacatecas.

TRIMEROTROPIS Stål

The genus *Trimerotropis* Stål, composed of many interesting and handsome species, finds its optimum development in the arid wastes of the Southwest. Minnesota, Michigan and other mid-western states have about two species each dwelling in arenicolous habitats; Alberta, North Dakota, South Dakota and Kansas have about eight each; Montana eleven and Colorado eighteen. Nevada, Arizona and California have each a large number of species. Texas has fourteen species, which are confined mainly to southwestern arid portions of the state.

KEY TO THE SPECIES OF TRIMEROTROPIS OF TRANS-PECOS TEXAS

1. Wing disc yellow 2
   Wing disc bluish green (new record) ..... *cyaneipennis*
2. Black band on the wing very broad; broader than the yellow disc 3
   Black band narrow 4
3. Band exceedingly broad occupying 2/3 the total wing length; the disc 1/3 the width of the band, abdominal and thoracic sternites salmon pink ..... *melanoptera*
   Band very broad occupying ½ the total wing length; disc ¼ the width of the band; abdominal sternites only salmon red, thoracic sternites whitish ..... *latifasciata*
4. Hind tibiae yellowish 5
   Hind tibiae red or orange red 6
5. Posterior lateral lobes of the pronotum with a small downward projecting tooth; size small ..... *texana*
   Posterior lateral lobes of the pronotum rounded; size medium ..... *pallidipennis*
6. Antennae unusually long and heavy; size very large ..... *magnifica*
   Antennae normal and slender for the genus; size medium 7
7. Body color uniform greyish or brownish with indistinct tegminal bands (sand areas) ..... *citrina*
   Tegminal bands conspicuous 8
8. Size small for genus; posterior lateral lobes of the pronotum usually with a small tooth ..... *strenua*
   Size large; lateral lobes without a tooth 9
9. Tegminal bands uniform, widely spaced, even margined and three in number; body color with a pinkish or lavender tinge; habitat stony soil ..... *pistrinaria*
   Tegminal bands less uniform with uneven margins and made up of aggregations of annuli; color greyish without lavender tinge; habitat campestrian; wing band broader than the average for this group ..... *laticincta*

TRIMEROTROPIS TEXANA Bruner

Presidio, 8, VII, 29, 20 ♂♂, 7 ♀♀ (♂♂ in Univ. of Minn. Cln.; all taken in sands of Cibolo arroyo bed). 18 miles north of Presidio, 29, IX, 29, 1 ♂ (arroyo bed). Chinati Mts. (1), 12, X, 29, 1 ♂ (arroyo bed). 20 miles north Chisos Mts., Brewster Co., 18, VII, 30, 1 ♂, 1 ♀ (Hebard Cln.). 1 mile north of Persimmon Gap, 23, X, 46, 1 ♀. 5 miles south of Boquillas-Chisos road junction, 28, X, 46, 1 ♀ (base of hill). Well 10 miles northeast of Government Springs (Wadi Burnum Ranchhouse),

23, X, 46, 1 ♂ (small arroyo). 10 miles north Yselta, El Paso Co., 31, X, 46, 1 ♀ (sand dune area). West base Hueco Mts., 25 miles east of El Paso, El Paso Co., 9, X, 46, 1 ♀. White Sands Nat'l Monument, New Mexico, 6, X, 46, 1 ♂, 1 ♀.

T. texana is one of the smaller species of this handsome genus and falls into the same group with the same general characteristics as *T. bilobata* of the Great Basin Desert and *T. cristata* of the Colorado Desert, the latter a subdivision of the Sonoran Desert. The members of this group or triad exhibit close relationships to the genus *Conozoa* Saussure, and in fact has at times been included in it. McNeill gave the name *Pseudotrimerotropis* to this section of the genus.

T. texana was common at Presidio in a small colony restricted to the coarse sandy bed of Cibolo arroyo, being rare in similar locations in the Chinati Mountains. This species is strictly saxicolous in its habitat preference.

T. texana in its range rather closely outlines the distribution and extent of the Great Chihuahuan Desert. The male type came from El Paso, Texas and the allotype from Las Cruces, New Mexico. It occurs as far north in New Mexico as Socorro and Corizozo and west to Deming. In addition to the records listed above the writer took a specimen of *T. texana* in the northern part of the state of San Luis Potosi, northeastern Mexico, in August of 1940. It is thus seen to be a member of the Chihuahuan Lower Sonoran fauna.

†† TRIMEROTROPIS CYANEIPENNIS Bruner

Mt. Livermore, Davis Mts., 29, IX, 31, 2 ♀♀ (rocky creek bed at about 7500 feet elevation in wooded situations); 1 ♀ (Hebard Cln.). Camas Prairies, Idaho, 1 ♂, 1 ♀ (Univ. of Minn. Cln.).

T. cyanea Scudder, is a synonym.

These are the first specimens of *T. cyaneipennis* to be recorded from Texas. It has previously been reported from high altitudes in the Organ and Sacramento Mountains of New Mexico by Rehn and Hebard. The species is a member of the Southwestern Mountain group of the Transition Zone, and is found at high elevations in the Southwest usually in wooded retreats. The writer has captured it at 7500-8500 feet elevation in the Santa Catalinas, Santa Ritas, Huachucas, Hualpai and other mountain ranges of Arizona. In addition *cyaneipennis* ranges north from Arizona to Utah and southern Idaho, and is reported from the Providence Mountains of California.

The Texas specimens are very dark in body color and the wing disc dull bluish green with the apex of the wing infumate; in this respect much more highly tinged with greenish than specimens from southeastern Arizona which are bluish green; Oak Creek Canyon specimens are almost blue winged.

TRIMEROTROPIS PALLIDIPENNIS PALLIDIPENNIS (Burmeister)

Presidio, 21, IX-21, X, 28, 2 ♂♂, 7 ♀♀. Chinati Mts., 27, IX, 31, 2 ♂♂, 4 ♀♀ (Univ. of Minn. Cln.). Specimens from the Minn. Cln. are from Douglas, Arizone; Portland, Oregon; Lodi, California, and the Brennen Islands, California and in the Tinkham Cln., from Twin Falls, Idaho; Overton, Nevada; and Modena and Milford, Utah.

A common synonym of this species in the literature is Scudder's *T. vinculata.*

This, the most ubiquitous of desert acridians, is found abundantly in every

desert locality visited by the writer during his expeditions to the Southwest in 1930, 1931, 1938 and 1939. It is found throughout Nevada, California east of the Sierra Nevadas south to the tip of Baja California and everywhere along the southern border of the United States from the Pacific to western Texas. East of the Rockies it extends north to northern Colorado and Kansas where it merges with the northern plains race *T. pallidipennis salina* which extends north to the plains of the Canadian Prairie provinces and has in one instance been taken in northwestern Minnesota. This species is a member of the Upper and Lower Sonoran fauna and is often taken in the Transition Zone in stony environments which is its typical habitat.

TRIMEROTROPIS CITRINA Scudder

Presidio, 15, IX, 28, 1 ♂; 28, VI, 29, 1 ♂; 4, VIII, 29, 1 ♀; 23, X, 28, 1 ♀. Ochoa, 8 miles up river from Presidio, 23, X, 28, 1 ♀ (Univ. Minn. Cln.). Chinati Mts., (1), 18, X, 46, 2 ♂♂. Lower Limpia Canyon, 20 miles southwest of Balmorhea, 12, X, 26, 3 ♀♀ (one female teneral; arroyo sands). Mouth Upper Limpia Canyon just north Ft. Davis, 13, X, 46, 2 ♂♂, 2 ♀♀ (sandy arroyo banks). 6 miles northeast Ft. Davis, 12, X, 46, 1 ♂. Chinati Mts., 3 miles west of Shafter, 19, X, 46, 1 ♂.

This species was recorded by Hubbell, in 1925, as the synonymous *T. rubripes* Rehn, from Phantom Lake, Jeff Davis County, Texas.

T. citrina is a sand loving species occurring in the Rio Grande Valley as north as Albuquerque, New Mexico, and from the Valley east to the Atlantic and south to the Gulf Coast. Its northern limit of distribution runs from Kansas and central Nebraska northeast to Indiana, the "Neck" of Pennsylvania and thence to the Atlantic. The writer found this species quite abundantly along sandy country roads near Tallulah, in northeastern Louisiana, in 1928.

TRIMEROTROPIS PISTRINARIA Saussure

Chinati Mts., (1), 30, IX, 28, 4 ♂♂; 29, X, 28, 1 ♂; 4, VIII, 29, 4 ♂♂, 3 ♀♀; (7), 27, IX, 31, 1 ♂. Desert 20 miles north of Chisos Mts., Brewster Co., 18, VII, 30, 1 ♀ (Hebard Cln.). Wilson's Ranch, west base of Mt. Emory, Chisos Mts., 17, VII, 30, 1 ♂ (elev. about 5000 feet). Pine Springs, New Mexico-Texas line, 19, VII, 30, 7 ♂♂, 5 ♀♀ (Hebard and Tinkham Clns.). Chinati Mts. (1), 16-18, X, 46, 5 ♂♂, 4 ♀♀ (rarer than in 1929-1930). 3 miles west of Shafter, 19, X, 46, 1 ♂, 1 ♀. Dead Horse Mts., Brewster Co., 23, X, 46, 2 ♂♂.

This species has been known for many years as *T. bruneri* McNeill, until Hebard, in 1931, placed it in synonymy. McNeill's *praeclara* is another synonym.

The specimens from the Big Bend Region represent the optimum of the race, being almost twice the size of those the writer has collected in southern Alberta; purely an environmental response.

The distribution of *pistrinaria* is confined to the Great Plains east of the Rockies, extending from southern Alberta to Texas and east to western North Dakota and central South Dakota, Nebraska and Kansas. In the Southwest it ranges into southeastern Arizona.

Typically Transitional in distribution this species in the Big Bend was found only on a certain hilltop (elev. about 4500 feet) on the south side of the Chinati Mountains, where resurrection plants terraced the whitish clay soil to aid in the conservation of soil as well as moisture. Grass was scarce in such a

habitat. One wonders which is the greatest controlling factor or factors in the habitat in limiting the distribution of an insect: host plant, habitat or temperature, or a combination of several factors. For *pistrinaria* type of habitat plays an important rôle in determining the distribution of this species. These optimum specimens on account of their large size may prove to be a race, in which case *bruneri* would be retained as the northern race.

TRIMEROTROPIS LATICINCTA Saussure

Six miles east of Marfa, 22, VI, 30, 1 ♂, 1 ♀. Davis Mts., plains at base of hills 15 miles northwest of Marfa, 29, IX, 31, 1 ♀. Ten miles west of Marfa, 30, X, 46, 6 ♂♂, 5 ♀♀ (common with *T. melanoptera* and few *T. magnifica*).

Hebard (1932b) concerning material of this species from Allamore and Marfa, Texas, states that specimens of this species from the Big Bend Region and also from Mexico, have an appearance quite distinct from Great Plains series. The Marfa specimens are large and moderately robust, with long tegmina having distinct but not uniformly solid bands. The body color is medium gray. Revision may assign to these specimens racial status.

The distribution of *laticincta* on the Great Plains extends from the southeastern corner of Alberta to Wichita Falls, Texas, and east of the Rockies to western North Dakota, central South Dakota, Nebraska and Kansas and the western border of Oklahoma. It occurs rarely on the Marfa Plains which undoubtedly connects with the Great Plains through the grasslands of eastern New Mexico. Hebard (1932b) records it from Rodriguez, in the Mexican state of Nuevo Leon.

†† TRIMEROTROPIS STRENUA McNeill

Eight miles east of Van Horn, Texas, 2 ♂♂, Oct. 23, 1943 (on gravelly soil on creosote covered mesa). 11 miles north of Pecos, Texas, 12, X, 46, 3 ♂♂. 20 mi. W. of Valentine, 30, X, 46, 1 ♂.

These are the first Texas records and the first records east of Arizona for this interesting desert species.

T. strenua closely resembles *T. p. pallidipennis* in size, coloration and markings but differs in having the caudal tibiae coral red and not buffish yellow. The posterior angle of the lateral lobes of the pronotum is usually armed with a minute tooth.

T. strenua is a member of the Lower Sonoran fauna and is now known from Trans-Pecos Texas to the desert areas of Arizona and from there extends its distribution into southwestern Utah, southern Nevada and the desert regions of California.

TRIMEROTROPIS LATIFASCIATA Scudder

Presidio, 24, VIII, 29, 1 ♂ (at light).

The single male identified by Mr. Hebard as this species was taken at night flying around a street light. Its orange red caudal tibiae and broad wing bands attracted immediate attention. It differed strikingly from *laticincta* by its much smaller size, more contrasting coloration and by the breadth of the wing bands.

T. latifasciata is hardly distinguishable from *T. melanoptera*. The salmon red of the abdominal sternites does not extend onto the thorax, whereas in *melanoptera* the salmon pink suffuses the entire ventral sternites of thorax and abdomen. The narrow yellow disc is slightly broader in *melanoptera* being 1/3 instead of 1/4 the length of the wing as in *latifasciata*.

This species is a member of the Southwestern Grasslands fauna ranging from the Big Bend Region to southeastern Arizona and in its typical habitat is closely associated with the closely related species *T. melanoptera*. *Latifasciata* is also recorded from the Great Basin area of Idaho, Utah and Nevada.

TRIMEROTROPIS MELANOPTERA McNeill

Davis Mts., 22, X, 28, 2 ♂♂, 1 ♀; 3 ♂♂ (Univ. of Minn. Cln.). Marfa, 4-5, X, 29, 2 ♂♂, 3 ♀♀; 1 ♂, 2 ♀♀ (Univ. of Minn. Cln.). Ten miles west of Marfa, 30, X, 46, 12 ♂♂, 9 ♀♀ (common in grasslands especially along dirt ridges).

This species cannot be mistaken for any other oedipodine of the region, except *latifasciata*, for reasons of its extremely broad wing bands. The dark body color, coral red caudal tibiae and the salmon pink suffusions of the under parts of the body makes it a conspicuous species. It is a very common species on the grasslands of the Davis Mountain region, especially at about 6000 feet elevation. In October of 1929 *T. melanoptera* and *Arphia crassa* were extremely abundant and presented a striking picture as they flew up in swarms with the bright red and black and heavily banded yellow wings. *Arphia crassa* was the more abundant and there were large numbers of other species such as *Melanoplus gladstoni* and *Drepanopterna femoratum*.

T. melanoptera is a member of the Southwestern Grasslands fauna extending from the Davis Mountains to southeastern Arizona and north as far as Hugo, Colorado. In Arizona it prefers narrow gravelly ridges and the bare areas around the ant colonies of *Pogonomyrmex* for its especial habitat. Hebard, in 1932, records it from Nogales, Sonora, and Escuinapa, Sinaloa. The type locality for *melanoptera* is Silver City, New Mexico.

TRIMEROTROPIS MAGNIFICA Rehn

Marfa, 4, X, - 5, X, 29, 2 ♂♂, 2 ♀♀. Prairie 8 miles south of Marfa, 22, VI, 30, 1 ♂, 1 ♀. Prairie, 15 miles north of Marfa, 29, IX, 31, 1 ♀; 1 ♀ (Univ. of Minn. Cln.). 10 miles west of Marfa, 13, VIII, 40, 1 ♂, 1 ♀; 30, X, 46, 3 ♂♂, 2 ♀♀.

This species described by Rehn, in 1908, from the Huachuca Mountains in southeastern Arizona, is the largest species of the genus. It is distinguished from other species by its unusually long and heavy antennae and in this respect closely resembles *Hadrotettix trifasciata*. It is, however, not as robust as *Hadrotettix*, with longer tegmina and with the tegminal bands less contrastingly defined. The two species can be easily separated in the field on the color of the internal proximal face of the caudal femora; that in *Hadrotettix* is bluish black whereas *magnifica* is reddish black.

Should a revision be given the genus *Trimerotropis*, the many features separating *magnifica* from the other species of the genus may be sufficient to warrant placing it in a genus by itself.

T. magnifica is a member of the Southwestern Grasslands fauna of the Upper Sonoran ranging from the grasslands of the Big Bend Region to southeastern Arizona, where it is very rare, north to southeastern Colorado and the southwestern corner of Kansas.

HADROTETTIX TRIFASCIATA (Say)

Davis Mts., 4-5, X, 29, 1 ♂, 2 ♀♀. Grassy gulch (9), 34 miles north of Presidio, 22, VI, 30, 1 ♂. Chinati Mts., (3), 27, IX, 29, 1 ♀. Prairie 8 miles south of Marfa, 22, VI, 30, 1 ♂, 2 ♀♀. Chinati Mts., (7), 27, IX, 31, 6 ♀♀. Marfa, 28, IX, 31, 5 ♀♀. Davis Mts., Cox's Ranch, 29, IX, 31, 1 ♀. Marathon, Brewster Co., 26-27, VIII, 12, 1 ♂ (Rehn and Hebard). 9 miles east of Marfa, 29, X, 46, 1 ♀. Davis Mts., Prudes Ranch, 13, X, 46, 3 ♀♀.

This is a characteristic and easily recognized member of the Great Plains fauna on account of its large robust size, uniform grayish or pinkish or bluish gray coloration with three broad and widely spaced even tegminal cross bands. The antennae are unusually long and heavy for an oedipodine.

Hadrotettix trifasciata has an extensive distribution on the Great Plains east of the Rockies. It ranges from southern Alberta and Saskatchewan south to Texas and east of the Rockies to central North and South Dakota, Nebraska and the eastern borders of Kansas and Oklahoma. In the south it occupies the grasslands of the Panhandle, extending throughout New Mexico to southeastern Arizona, northern Chihuahua, Mexico, and the semi-arid rangelands of the Big Bend Region. Only in western Montana does its distribution extend through the Rocky Mountains. This species is common in the Big Bend area dwelling as it does in its typical habitat of sparse grass on rocky soil. In North Dakota the gravel pits carry its distribution into the central part of the state yet in the surrounding territory outside the pits no specimens can be found. The species is typically Transition and Upper Sonoran; its saxicolous nature probably accounts for its wide distribution.

†† HELIASTUS BENJAMINI Caudell

Cibolo Arroyo, 2 miles above Shafter, 9, IX, 29, 1 ♀ (stones of arroyo; elev. c. 4300 ft.). Davis Mts., Lower Limpia Canyon, McCutcheon's Ranch, 4, X, 29, 6 ♂♂, 8 ♀♀ (common on stones bordering streams). Upper Limpia Canyon, (19), 5, X, 29, 4 ♂♂, 4 ♀♀ (gravelly arroyo bed at about 6000 ft.). 3 miles west mouth Upper Limpia Canyon, 13, X, 46, 3 ♂♂, 1 ♀. Davis Mts., Cox's Ranch, south base Mt. Livermore, (20), 29, IX, 31, 1 ♂, 2 ♀♀ (rare).

This beautiful species is easily recognized by its bluish gray coloration, banded tegmina, and wings of delicate rose pink hue.

The above Texas specimens constitute the first Texas records. The species was described from the Huachuca Mountains of southeastern Arizona and is commonly found in gravelly arroyo beds of the Santa Ritas, Santa Catalina and other ranges of southeastern Arizona and in typical habitats in the Sonoran Live-Oak belt in Sonora and Sinaloa, Mexico. In the arroyos it is often associated with *Platylactista aztecus*.

Heliastus benjamini was common in the Limpia stream bed of the Davis Mts., in 1929 but appeared rare in 1931, and in October, 1946, could not be found in its former favorite habitat, Lower Limpia Canyon, and only very

rarely in Upper Limpia Canyon, due to the great changes wrought by erosion in the fifteen-year period. An unusual ectogene was the Shafter specimen taken in typical Lower Sonoran environment. It was found in the early morning perched upon a small boulder in the rocky arroyo bed sunning itself. Hebard (1935a) records this species from Chimayo in northern New Mexico. It belongs to the Mexican Upper Sonoran fauna.

CIBOLACRIS PARVICEPS (F. Walker)

Presidio, 18, IX, 28, 1 ♂, 1 ♀; 21, IX, 28, 1 ♂, 1 ♀; 13, VIII, 29, 1 ♀. Mesas 12 miles north of Presidio, 30, IX, 28, 2 ♂♂. Indio, 3, V, 30, 1 ♂, 1 ♀. Presidio, 2, VII, 29, 1 ♀ (rocks along shores of Rio Grande). Chinati Mts., (3), 8, VI, 30, 1 ♀; (7), 27, IX, 31, 1 ♀. Dead Horse Mts., Brewster Co., 23, X, 46, 1 ♂, 1 ♀. 11 miles north Pecos, Reeves Co., 12, X, 46, 1 ♂.

This species has long been known in the literature as *Heliastus aridus* Bruner, but Hebard (in 1931) after Uvarov had referred *parviceps* to the *californicus-aridus-minimus* group of the genus *Heliastus*, showed that *aridus* was a synonym of *H. parviceps*.

This species, common everywhere on the desert, is decidedly saxicolous in the choice of habitat. It shows considerable variation in color; some specimens being chalky white, others stone gray and still others stone gray profusely sprinkled with fine specks.

C. parviceps is a true inhabitant of the Lower Sonoran Zone occupying the deserts of southwestern Texas and northern Chihuahua. It extends up the Rio Grande Valley to Albuquerque and the Otera Basin to Alamogordo. In the Southwest it is found throughout the desert regions of Arizona, southeastern California north to central Nevada and the southwestern corner of Utah. In Mexico it is found far south in Baja California, Sonora and Sinaloa, Coahuila and Chihuahua.

ANCONIA HEBARDI Rehn

Indio, 28 ♂, 18 ♀♀ taken the following dates: 19, IV; 3, V; 5, V; and 15, V, 30 of which 1 ♂ is in the University of Minnesota Collection and 9 ♂♂, 3 ♀♀, in the Hebard Collection.

This rarest and most beautiful of desert oedipodines was previously known only from the original small series taken in the vicinity of El Paso, Texas, by Rehn and Hebard, in July of 1907.

At first confused with its near relative *Anconia caerulepennis*, known only from Nevada, and to which it bears a close resemblance this species was described by Rehn in 1917.

Since the capture of the original small series *Anconia hebardi* has escaped discovery (despite efforts to secure it) until the spring of 1930 when the writer found this colony near Indio, up the Rio Grande Valley from Presidio some 22 miles.

Anconia hebardi is one of the handsomest actidids to be found in the southwestern United States. The wings are a beautiful azure like the desert sky of its home and this prevents the species from being mistaken from any other species of the entire region.

The habitat was restricted to a small arroyo bed and the adjacent gravelly areas on the adobe flat at the base of the mesa (Fig. 26). The few plants in

the immediate vicinity were mainly dense clumps of low mesquite and small isolated bushes of *Atriplex* sp. probably *canescens*. Many males were taken in the arroyo bed where their bluish gray bodies blended perfectly with the bluish gray stones of the arroyo and only by disturbing them and approaching the exact spot where they had alighted were they captured. The males were not in the habit of flying far when disturbed; usually flying ten or fifteen feet and

Fig. 26.—Habitat of *Anconia hebardi* Rehn, at Indio, Presidio County, Texas.

then alighting. The females which were less abundant were much more wary and difficult to catch. When escaping capture by the net they would fly high into the air in a rapid zigzagging fashion to about a height of thirty or forty feet and then would suddenly light at some forty to fifty yards distance. When less violently disturbed they were accustomed to fly a shorter distance, but always much further than the males. This species when alighting makes a faint crackling noise. Any males within a radius of eight or ten feet of an alighted female, usually approached her by a series of several short hopping flights and then at a distance of one to two feet more warily approached her.

On April 19, one or two last instar nymphs were present and on June 9 the species had disappeared for the year. This species is an early spring form; this fact accounting for the failure of collectors, who arrive in mid and late summer, to rediscover the species.

Anconia hebardi is a member of the Chihuahuan Sonoran fauna and is definitely restricted to extreme southwestern Texas, as it is known from only El Paso and Indio, Texas.

PAMPHAGINAE

Prior to 1941 the Nearctic genus *Phrynotettix* Glover, rested for many years in the Gerontogeic subfamily Batrachotetriginae. In 1941, Roberts erected the new subfamily Romaleinae, including in it lubbers and toadhoppers of the Nearctic genera *Romalea, Taeniopoda, Brachystola, Phrynotettix, Tytthotyle* and many others. In 1943, Uvarov of the British Museum published an exhaustive treatise on the tribe Thrincinae of the subfamily Pamphaginae and the interrelations of the acridid subfamilies. From his study it was necessary to unite the Batrachotetriginae with the Thrincinae to form a tribe within the Pamphaginae. To include certain Nearctic genera, such as *Phrynotettix, Dracotettix,* and *Litoscritus,* the Chilean *Aucacris* and the Australian *Buforania* he proposed the tribe Phrynotettigini representing by the sum total of their characters, a sort of connecting link between the Pamphaginae and the Catantopinae or Cyrtacanthacrinae.

While in Korea with the army, I had occasion to study, in 1946, living specimens of *Haplotropis brunneriana,* the northeasternmost Asiatic genus of the Pamphaginae. One of the most interesting and diacritical characters of the Pamphaginae is Krauss's organ, situated at the anterio-lateral margin of the first abdominal tergite in both sexes. Krauss's organ is variously ribbed and shaped in the different genera and its purpose has been debated by Graber, Brunner, Krauss, Zeuner, Uvarov and others, and its function as a sound-producing organ has been denied by Uvarov and Brunner or thought to be something of an airpressure organ by Zeuner. My preliminary studies indicate that Krauss's organ is an organ of sound for when annoyed *Haplotropis* throws its hindlegs up over its back and in so doing produces an audible rasping sound as the rough surface at the base of the inner pagina of the caudal femora rub across the corrugated ribs on Krauss's organ. *Phrynotettix* exhibits this same characteristic although the sound produced is slightly less audible. This sound may have some function in mating, substituting for "leg stridulation" in the Acridinae, "crackling of wings" in the Oedipodinae, "clacking of wings and tegmina" in *Romalea* and *Taenipoda,* and the "rubbing of wing and tegminal pads" in *Brachystola.* In *Haplotropis* Krauss's organ is underlain by an air cavity plentifully supplied by numerous anastomosing tracheae. It is believed that the tympana interpret the sounds produced by Krauss's organ. Critical studies on Krauss's organ have not been made on *Phrynotettix* at this stage, but its presence is significant. As Roberts (1941a, p. 231) has aptly said "the loss or suppression of a structure is a relatively frequent and simple occurrence in contrast to the development of a new type or form of structure. Thus the presence of a structure may be quite significant, but its absence should be treated as entirely negative." Hence the presence of Krauss's organ in *Phrynotettix* should mean only one thing—that it is a member of the Pamphaginae. Nor should the zoogeographers object or be surprised at a pamphagid grasshopper of an eremiophilous nature dwelling in North America, for Dr. Melander has recently described numerous new deserticolous species of the dipterous genera, *Oligodranes, Empidideicus* and *Apollysis* which are all of Mediterranean origin. Since the description of Engel's new asilid genus and species

Haplopogon nudus from Turkestan, in 1930, two Texas species have been discovered and described. The writer has recently described seven new Chinese species of the decticid genus *Atlanticus* bringing the Asiatic species to ten in comparison to nine earlier described Nearctic species.

As taxonomists and students of zoogeography bring to light new finds and make closer comparisons of Gerontogeic and Neogeic genera and species, many new associations will be found typical of *Phrynotettix*.

PHRYNOTETTIX Glover

The grasshoppers of the genus *Phrynotettix*, as the Greek name indicates, are called "Toadhoppers" because in their fat clumsy appearance and interesting habits they somewhat resemble "horned toads" or horned lizards. Texas is fortunate in having the two known species of this unique genus. *Haldemanella* Saussure is a synonym.

KEY TO THE SPECIES OF PHRYNOTETTIX OF TRANS-PECOS TEXAS

1. Inner face of caudal femora white, tibiae white, smooth and not pilose; tegmina in male oval-elongate in shape, dark gray with white spots, in female tegmina mere pads; wings in male shining black, plectate; body color white or stone gray. The Texas toadhopper ..... *robustus*

   Inner face of caudal femora black, tibiae black and pilose, ventral parts of body pilose; tegmina mere obovate pads in both sexes; body color dark brown or rust brown. The Arizona toadhopper ..... *tschivavensis*

PHRYNOTETTIX ROBUSTUS (Bruner)

Paisano, Presidio Co., 23, VI, 29, 1 ♀. Desert mesa near Presidio, 8, V, 29, 1 ♂, 1 ♀ (in copulo). Chinati Mts., 8, IX, 29, 2 ♂♂, 1 ♀; 23, IX, 29, 1 ♂, 1 ♀ (elev. c. 4200 ft.); 1, VI, 30, 1, ♂; 17, X, 46, 3 ♀♀. Chinati Mts., (7), 27, IX, 31, 2 ♂♂, 2 ♀♀. Elephant Rock, 28 miles north of Presidio, Texas, 22, VI, 30, 1 ♂. Limestone hill just east of Cooper's Store, Brewster Co., Texas, 28, X, 46, 1 ♂, 1 ♀, 2 ♀♀ nymphs. Chisos Basin, Chisos Mts., Brewster Co., Texas, elev. 6000 ft., 24, X, 46, 1 ♀ nymph (rare on south facing rocky slope of Pulliam Bluff). Sierra Diablo Mts., 10 miles north of Van Horn, Texas, 31, X, 46, 1 ♂ nymph. Hueco Mts., 25 miles east of El Paso, Texas, 9, X, 46, 1 small nymph; 1, XI, 46, 1 ♀ nymph. Twenty miles north of Pecos, Texas, 13, X, 46, 1 ♀. Pine Springs near Texas-New Mexico line, 19, VII, 30, 1 ♂ (Hebard Cln.); 10, X, 46, 1 nymph (squatting on rock for night).

The Texas toadhopper is very rare in collections and this series recorded here and the results of many years collecting, is without doubt the largest ever taken. This species is found throughout the year in the nymphal stage as the nymphs hibernate, and the adults are found from May to November or December. Its stone gray coloration matches perfectly with the stones of its preferred habitat, the limestone hills and mountain slopes and sometimes the valley floor of the Chihuahuan Desert. The nymphs and adults spend the night tightly pressed against a small slab of limestone or whitish stone, which they match perfectly, their antennae pressed down and back along the sides of their thoraces and their legs tucked in closely to their bodies. In this camouflaged position they are very difficult to spot except with a well-trained eye.

P. robustus is an endogene of the Lower Sonoran Faunal Zone and a particular development of the Chihuahuan Desert. It is found in the desert regions of Trans-Pecos Texas ranging north to the New Mexico line north of Pecos and at Pine Springs and northwest to the Sierra Diablo and the Hueco Mountains east of El Paso. In Mexico the writer has taken it in southern Coahuila and Hebard has reported it from Moctezuma and Casas Grandes, Chihuahua.

PHRYNOTETTIX TSCHIVAVENSIS Haldeman

Shafter Mt., Chinati Mts., 30, IX, 28, 1 ♀ (elev. c. 5200 ft.), Chinati Mts., 23, IX, 29, 2 ♀♀, 6, VII, 30, 1 ♀ (elev. c. 6000 ft.); 27, IX, 31, 1 ♂, 1 ♀. Marfa, 4, X, 29, 1 ♀. 12 miles north of Marfa, Presidio Co., 13, X, 46, 1 ♀. Prairie 12 miles northwest Marfa, 28, IX, 31, 1 ♂. Desert 34 miles north of Presidio, 22, VI, 30, 1 ♂. Paisano Pass, Presidio Co., 31, X, 46, 1 ♂, 1 ♀, 9 miles west of Alpine, Brewster Co., 31, X, 46. 3 miles east of Alpine, 21, X, 46, 1 ♀ (rocky knoll covered with *Acacia roemeriana*). Franklin Mts., El Paso Co., Mellikan Canyon, 18, IX, 31, 4 ♂♂, 1 ♀ (elev. c. 4400 ft.); 8, X, 46, 1 ♂ (very rare in same habitat as 1931 collections). Mouth of Water Canyon, Magdalena Mts., New Mexico, 25 miles west Socorro, 23, VII, 30, 1 ♀ (elev. c. 7100 ft.).

Synonyms: verruculatus Uhler, *magna* (Thomas). *Taosanus* Rehn, may prove to be a dwarf biological-geographic race of the Mogollon Plateau.

The Arizona toadhopper is a representative of the Upper Sonoran and Transition Zones and is found most commonly on mountain slopes with a sparse coverage of grass. Its coloration mimics that of its habitat varying from rust red to brownish gray depending on the color of the rocks of its habitat. The adults appear in July and live until November; the eggs laid in the fall, overwinter, and hatch into nymphs the following spring. Females lay up to 28 eggs per pod.

The distribution of the Arizona toadhopper ranges from the Big Bend Region, where it is quite uncommon, westward to the Baboquivari Mountains of Arizona. In south central Arizona it is found in the Santa Rita, Tumacacori, and other ranges in Upper Sonoran environment and it is found very rarely in the Tucson Mts. in Lower Sonoran habitat. From south central Arizona it ranges north to the Mogollon Plateau where small-sized specimens are found from Williams to Springerville and east to the Magdalena Mountains of central New Mexico and adjacent ranges north to Taos. South of the border it is found in northern Sonora, Durango and southern Coahuila. It is a member of the Chihuahuan Upper Sonoran fauna as well as the Southwestern Mountain Transitional fauna.

ROMALEINAE

I have made no study of *Taeniopoda* or *Brachystola*, other than the eggs of these genera, and hence do not wish to express any opinion upon the subfamily status of the Romaleinae.

The eggs of *Taeniopoda* and *Romalea* are very closely similar, and quite distinct from those found in *Brachystola* and *Phrynotettix* although in these four genera the eggs are bipolar-capped. The eggs of the Acridinae, Oedipodinae and Cyrtacanthacrinae possess only a single cap. In these four genera, the second cap is sculptured in all but *Brachystola*, but the egg of *Phrynotettix*

despite the fact both shallow caps are sculptured, is still very different in form and sculpturation from *Taeniopoda* and *Romalea* which have deep cup-shaped caps.

Uvarov relegates the Romaleinae to its former status of a tribe within the Cyrtacanthacrinae (Catantopinae) but the writer is retaining for the present its subfamily rank until further studies can be made. There are certain peculiarities about *Taeniopoda* which are most interesting. When first picked up

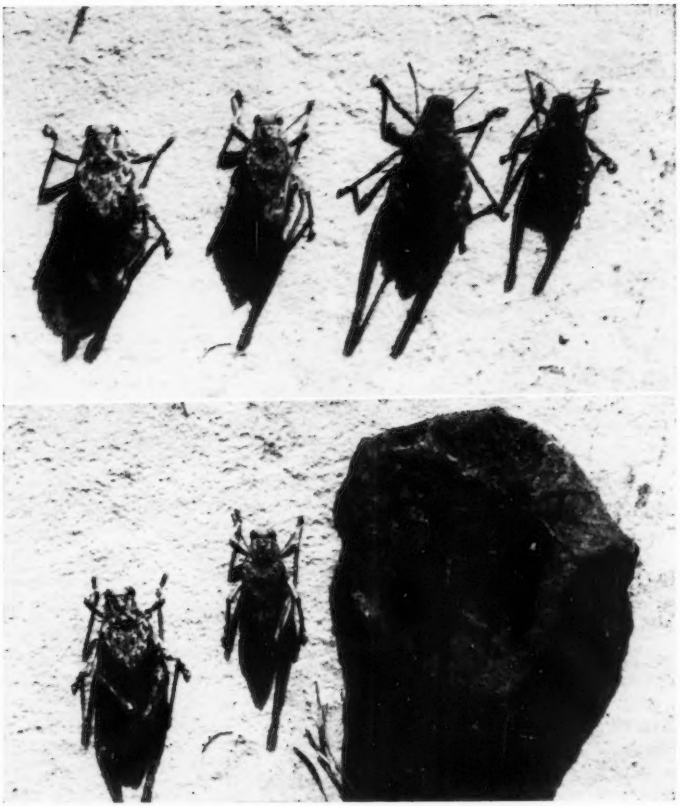


Fig. 27.—Illustration of camouflage effects in pamphagid toadhoppers of the genus *Phrynotettix*. Upper series depicts a pair of Texas toadhoppers, *P. robustus*, left, (on stone-gray limestone slab common in their habitat near Cooper's Store) with a pair of Arizona toadhoppers, *P. tschivavensis*, right, (found near Alpine on rust-colored volcanic rocks which they matched perfectly in coloration). Lower series shows the same specimens blending perfectly with rocks from their respective habitats.

Taeniopoda produces a hissing sound by blowing air out through the meso- and metathoracic spiracles, which may be a sort of defense mechanism. Further comparisons of *Taeniopoda* and related genera with certain Asiatic pyrgomorphines will be neecssary before a final decision can be made.

Brachystola although placed here at present, apparently has little if any relationship to *Taeniopoda.*

BRACHYSTOLA MAGNA (Girard)

Shafter Mt., 2 miles north of Shafter, Presidio Co., 30, IX, 28 (very common). Chinati Mts., 12, X, 29, 1 ♂; 27, IX, 31, 2 ♀♀, 1 ♀ nymph. Davis Mts., Jeff Davis Co., 29, IX, 31, 5 ♀♀. North side Davis Mts., 20 miles SW. Balmorrhea, 13, X, 46, 1 ♀ nymph. 9 miles east of Marfa, Presidio Co., 30, X, 46, 1 ♂. 3 miles east of Alpine, 21, X, 46, 3 ♂♂, 1 ♀ (common.).

Hebard established the synonymy of *B. intermedia* Br., in 1929.

Brachystola can be easily recognized by the tricarinate pronotum, the large and powerful legs and its saltatorial exhibitions, as well as the small round tegminal pad, red in color and spotted with black dots. *Taeniopoda* has fully developed flight organs, rose-red wings margined with black and the entire body surface is shining black with yellow markings on the pronotum and antennae and on the tegmina.

The "Prairie Lubber" as this species is called although I have heard it colled the "Homesteader" in Colorado, is well known because of its remarkable form and size. Despite its heavy weight males can often jump nine feet in a single leap. It is a common species on the Great Plains having as its northern limits Park City, Montana, Williston and Bismarck, North Dakota and Ortenville, Big Stone County, in western Minnesota. This latter is an astounding record as no specimens have been taken between Ortenville and central South Dakota. At Ortenville it appears to be confined to a rocky morainic ridge which undoubtedly serves as an ideal habitat. It would appear that the nature of the habitat is often very important in delimiting the range of the species of discontinuous distribution. A species dwelling in a gravelly habitat in Minnesota would find temperature conditions in the summer quite similar to a similar habitat in southwestern Texas; hence the nature of its distribution. Eastern limits of *Brachystola* are central Nebraska, Kansas and western Oklahoma, but its limits are undefined in Texas. In the Southwest it ranges from the Big Bend Region west to Cover Wells, Arizona and thence north to the north rim of the Mogollon Plateau. Hebard (1932b) records it from various places in Chihuahua and south to Durango. In the region of Magdalena, Sonora, the range of *B. magna* overlaps that of the larger Sonoran Desert species *B. ponderosa.*

In the Big Bend Region *B. magna* was common from the north side of the Chinati Mountains north to the Davis Mountains. Only one specimen during two years of collecting was taken in a valley two miles south of Shafter in typical Lower Sonoran environment. Here as an interesting ectogene its associated species were *Mermiria texana, Acantherus piperatus, Trimerotropis pistrinaria, Agroecotettix modestus crypsidomus, Phaulotettix eurycercus* and others. *B. magna* is a member of the Upper Sonoran Faunal Zone.

TAENIOPODA EQUES (Burmeister)

Chinati Mts., (3), 8, IX, 29, 1 ♀; 16, IX, 29, 1 ♂, 3 ♀♀; 23, IX, 29, 1 ♀. North base of Blue Mts., Chinati Mts., (7), 27, IX, 31, 3 ♂♂. Cutknife Flat, 30 miles north of Terlingua, Brewster Co., Texas, 29, IX, 28, 3 ♀♀ (W. L. Owen, Jr.). Chupadero Hills, 8 miles northeast of Presidio, 15, VI, 29, 1 nymph (Scout Paul Ornelas). Dawson's Ranch, 5 miles southeast of Shafter, Presidio Co., 8, VII, 29, 1 nymph. 10 miles north of the Chisos Mts., on Marathon-Boquillas Road, Brewster Co., Texas, 18, VII, 30, 4th instar nymph (E. R. Tinkham; Hebard Cln.). Green Gulch, Chisos Mts., 23, X, 46, 1 ♂.

T. burmeisteri Bolivar, is a synonym.

Only one species of this remarkable genus occurs within the confines of the United States, namely, *T. eques*, while about ten species occur from Mexico to Panama. *Romalea microptera* (Beauvois) of the southeastern United States does not occur west of Victoria on coastal Texas so that nowhere is the range of both species coincidental. *Taeniopoda* Stål and *Romalea* Serville belong to the group Taeniopodae which is composed of many large and strikingly colored species found mainly in Mexico and Central America. In 1924b, Hebard revised the genus, corrected the synonymy, and pointed out that much confusion existed in the literature between this species, *T. picticornis* (Walker) and *T. stali* Bruner.

T. eques cannot be mistaken for any other species in the United States. The body is shining black with narrow yellow marginal markings decorating the pronotum. The antennae are yellow annulated with black and the black tegmina appear embroidered with all the veins in citrous green. The wings, much shorter in the female than in the male, are beautiful deep rose red with considerable black at the apices.

When captured this species emits a peculiar hissing sound which is produced by taking in air through the abdominal spiracles and expelling it through the meso- and metathoracic spiracles. The hissing appears to be caused by the sudden expulsion of the air through the moist trachea since tiny droplets of moisture collect at the apertures of the thoracic spiracles. Duncan, in 1924, described in fuller detail this hissing sound. This species also makes a peculiar clacking sound by beating its wings together as it rests in some desert shrub. In Arizona its favorite food plants are mesquite, *Calliandra*, *Acacia* and *Mimosa* but the Texas food plants are not known. The overwintering eggs hatch in the spring and the nymphs become adult in the late summer. It is known as the horse lubber.

T. eques is confined to the Big Bend Region of Texas, the southwestern corner of New Mexico and west in Arizona to the Ajo Mountains and north to San Carlos and Clifton. In Mexico it is found in northern Sonora and south from the Big Bend to Chihuahua, Nuevo Leon and southern Coahuila where I have taken it near Saltillo. It is also known from Jalisco. *T. eques* is a member of the Mexican Lower Sonoran fauna.

CYRTACANTHACRINAE

The members of this large family, popularly known as the "Spine-breasted Grasshoppers" are characterized by a short, heavy, spine-like process located

between the base of the fore legs. Many species, especially members of the genus *Melanoplus*, are of great economic importance. One species, *Melanoplus mexicanus mexicanus*, the lesser or Rocky Mountain locust, is one of the most destructive insect pests in North America. In 1938 and 1939 the amount of its damage to the wheat crops of the Dakotas, Montana, and the Canadian prairie provinces ran into the tens of millions of dollars while seven million dollars were spent on control alone in 1939.

KEY TO THE GENERA OF THE CYRTACANTHACRINAE OF TRANS-PECOS TEXAS

1. Species winged although tegmina often minute and scale-like 2
   Species apterous; male sex very small, light tan with broad black post-ocular stripe evanescent on abdomen; female sex much larger and violet gray; caudal tibiae pinkish red in both sexes ..... *Netrosoma* Scudder
2. Frontal Costa strongly bowed out in front of eyes; face strongly receding; tegmina very narrow and elliptical, minute; color light to dark striated with gray ..... *Clematodes* Scudder
   Frontal Costa not strongly bowed out but straight 3
3. Large species exceeding two and one-quarter inches in length; form long and moderately slender with long tegmina and wings possessing strong flight powers; male subgenital plate deeply cleft at apex ..... *Schistocerca* Stål
   Male subgenital plate not deeply cleft; size always under two inches in length 4
4. Lateral margins of the male subgenital plate as seen from the side straight throughout or very narrowly convex, never abruptly ampliate at the base 5
   Lateral margins of the male subgenital plate suddenly ampliate at the base, or the entire margin rather strongly convex or sinuate 9
5. Male subgenital plate with a slight but distinct apical tubercle 6
   Male subgenital plate with no apical tubercle 7
6. Size small, dark brown in color with black post-ocular stripe; tegmina ovoid, head normal in size; caudal femora green; caudal tibiae bluish green ..... *Phaedrotettix* Scudder
   Size medium, entire body, legs and tegmina yellowish green; body surface pilose; head prominent due to constricted pronotum; tegmina oval-lanceolate and about equal to that of the pronotum; prosternal spine retrorse ..... *Camplyacantha* Scudder
7. Size medium, pronotum black with a median white line; tegmina small and oval ..... *Philocleon* Scudder
   Size medium to larger, pronotum tan or gray with darker mottling 8
8. Size medium; tegmina narrowly elliptical; cerci tapering moderately with only a slight enlargement on the distal one-quarter which is bluntly rounded; body color tan or dark brown with post-ocular band extending to principal sulcus of the pronotum; caudal tibiae pink ..... *Phaulotettix* Scudder
   Size slightly larger; tegmina oval; cerci bifurcate with broadly rounded upper digit and spike-like lower spur; color dark brown with darker blotched markings; caudal tibiae red ..... *Agroecotettix* Bruner
9. Head large in proportion to pronotum which is slightly subsellate and flaring in front to receive the head; tegmina oval-lanceolate and about the length of the pronotum although macropterism sometimes occurs; subgenital plate long and narrow, the margin not apically elevated, apex with a small tubercle; cerci styliform ..... *Photaliotes* Scudder
   Head not large in proportion to the pronotum and not prominent, and but slightly longer than the prozona; pronotum not flaring in front nor subsellate; body form stout 10
10. Brilliantly colored species of medium stout size, colored in purple and yellow washed with red; tegmina ovoid ..... *Dactylotum* Charpentier

11. Male subgenital plate ending in a distinct subapical tubercle 12
Subgenital plate without a distinct subapical tubercle but often apically produced or tumescent ..... *Melanoplus* Scudder

12. Green in color with pinkish dorsal stripe on pronotum; sulci narrowly marked in black; wings fully developed; body form relatively slender; apical tubercle of male subgenital plate prominent; furculae present as distinctly projecting lobes; caudal femora with herringbone markings on pagina and with a pregenicular pink annulus ..... *Hesperotettix* Scudder
Species stouter than the above and of a sandy gray color with fully developed wings; apical tubercle not very prominent; furculae scarcely apparent; a thamnophilous species living in *Sacrobatus* ..... *Aeoloplus* Scudder

CLEMATODES LARREAE Scudder

Presidio, 9, IX, 28, 1 ♀ juv. (rocky base of mesa). Chinati Mts., (3), 4, V, 30, 1 ♀. Limestone hill near Cooper's Store, Big Bend Park, Brewster Co., 29, X, 46, 1 ♀ (swept from Creosote).

This very rare grasshopper is known in the United States from very few specimens; the above apparently the first for Texas. It has also been taken near Ajo, Arizona.

This, the creosote-stem grasshopper, is a member of the Mexican Lower Sonoran fauna and it is found in parts of southern Coahuila and northern San Luis Potosi where the writer found it in 1940. In this region vigorous sweeping of many creosote plants may yield one or two specimens.

This species is wingless with tegmina barely visible and the frontal costa is produced forward between the eyes to form a sort of a nose. The body form is slender and the color gray, profusely striated with dark gray longitudinally running lines which render it inconspicuous on the dark gray stems of creosote. Its interesting form and habits as well as its rarity make this species one of the most sought after of desert acridids.

KEY TO THE SPECIES OF SCHISTOCERCA OF TRANS-PECOS TEXAS

1. Species uniformly green with citrous-colored wings; caudal tibiae pale pink ..... *shoshone* (Thomas)
Species not uniformly green; wings pellucid or amber-colored 2

2. Species dark gray in color with indistinct mottlings on the tegmina; wings pellucid; size large and slender ..... *vaga* Scudder
Species not dark gray in color 3

3. Pronotum with a broad yellow post-ocular stripe in addition to a central yellow stripe on lateral lobes of the prozona; tegmina mottled with two or three blackish spots on the yellow ulnar field; caudal tibiae flesh-colored with brown-tipped whitish spines ..... *americana* (Drury)
Pronotum without a yellow post-ocular stripe; tegmina uniformly dark reddish brown with the yellow dorsal stripe of head and pronotum extending caudally to apices of tegmina; caudal tibiae blackish dorsal with the spines yellow tipped with black 4

4. Body coloration greenish-brown or brownish, not blackish; pronotum concolorous and lacking a yellow patch on lateral lobes of the prozona and seen in profile the crest not distinctly arcuate, but often subsellate; caudal femora with 2 indistinct cross bars above and the outer pagina greenish yellow or yellowish brown and unmarked; caudal tibiae blackish dorsally paling caudally and yellowish ventrally ..... *lineata* Scudder

Body dark, almost blackish; pronotum almost black with minute specks of yellow and a central patch of bright yellow on the lateral lobes of the prozona; pronotum in profile with crest distinctly arcuate; meso-epimeron with large rectangular patch of bright yellow; caudal femora with two black cross-bands above and with the outer pagina whitish gray with a black herringbone design; caudal tibiae ivory black dorsally and ventrally black at base shading to yellowish apically; head with face dark with yellow on side and subocular stripe black ....*chinatiensis* n. sp.

SCHISTOCERCA VAGA VAGA Scudder

Ochoa, 10, X, 28, 1 ♂. Chinati Mts., (7), 27, IX, 31, 1 ♂; 30, IX, 29, 1 ♀. Dead Horse Mts., 24, X, 46, 1 ♂. 1 mile north Persimmon Gap, Brewster Co., 23, X, 46, 1 ♂.

This wary and far-flying locust is more abundant than the records would indicate as it is more commonly seen than captured. In the Chinati Mountains up to elevations of 5000 feet it is a fairly common species. It is also the commonest species of *Schistocerca* in the Rio Grande Valley where many are to be seen in the cotton fields.

Schistocerca vaga belongs to the Lower Sonoran Faunal Zone and is found commonly along the southern border of the United States from Trans-Pecos Texas to western Arizona and California. Its northern limits more or less correspond to the northern limits of the desert. South of the border it ranges widely over Mexico and Baja California south to Nicaragua.

SCHISTOCERCA AMERICANA AMERICANA (Drury)

Presidio, 5, VI, 30, 1 ♀. Ft. Davis, Jeff Davis Co., 30, IX, 31, 1 ♀.

Walker's *Acridium vicarum* and *piceifrons* are synonyms as is also *Schistocerca serialis* (Thunberg).

This species is very rare in the Big Bend Region and the above localities mark its southwestern limit of distribution in the United States; Marathon was the previously known western limit in this area. East of the Big Bend the range of *S. americana* spreads eastward to coastal Texas and northeastward to the southwestern corner of Oklahoma and southeastern Kansas which mark its northern limits of continuous distribution in that latitude. East of these regions it ranges to the Atlantic Seaboard, and south into Florida.

As the season advances the species becomes restless and semi-migratory and many individuals are taken in far northern localities such as southern Ontario, Pennsylvania and Massachusetts, but these points are far north of its breeding grounds.

In northern Mexico *S. americana* ranges south between the eastern and western Sierra Madres to central Mexico where it spreads out and extends southward to Guatemala. It belongs to the Humid Lower Sonoran Faunal Zone but inhabits cultivated areas in the Lower Sonoran of southwestern Texas.

SCHISTOCERCA SHOSHONE (Thomas)

Candeleria, Presidio Co., 11, X, 28, 1 ♂. Presidio, 15, X, 28, 3 ♂♂; 5, VI, 30, 1 ♀. Lower Limpia Canyon, Davis Mts., 13, X, 46, 1 ♂ (*Baccharis glutinosa*).

This large uniformly green species with pale pink caudal tibiae is found not uncommonly in the cottonfields of the Rio Grande Valley from Presidio

to Candeleria. It is southwestern in distribution ranging from Trans-Pecos Texas and the Rio Grande Valley of New Mexico west to California and north to Utah, Nevada and Oregon. In Mexico it is found as far south as Sinaloa and the tip of Baja California. *S. shoshone* is a member of the Upper Sonoran Faunal Zone.

SCHISTOCERCA LINEATA Scudder

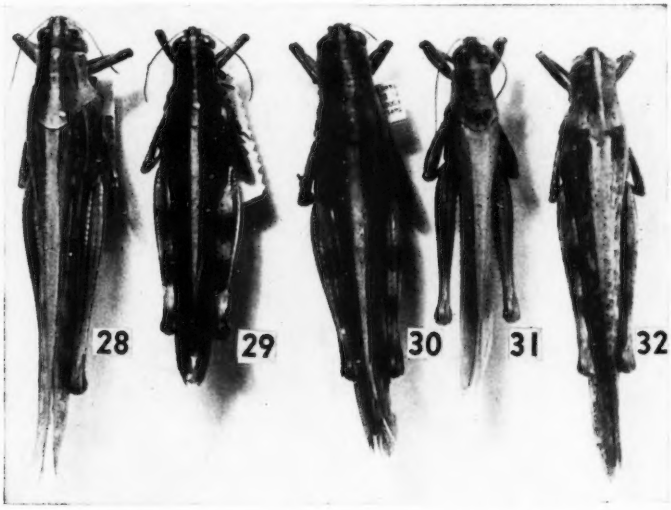
Base of Blue Mts., Chinati Mts., 27, IX, 31, 1 ♀ (elev. c. 5200 ft. in oak zone of *Quercus virginianiana;* north facing slope). Cox's ranch, S. base of Mt. Livermore, Davis Mts., Jeff Davis Co., 29, IX, 31, 1 ♀.

This large and interesting *Schistocerca* is very rare in the Big Bend Region for it was not discovered by the writer until 1931. The above records are the first for Trans-Pecos and indicate a southwestern distribution point in this area.

S. lineata ranges east of the Rockies from the southeastern corner of Alberta and southern Minnesota south to central Texas, southwest to the Chinatis, and west to central New Mexico and south into Mexico. A form of *S. lineata* is found around Nogales and the Tumacacori Mountains of southern Arizona.

Schistocerca chinatiensis n. sp. Figs. 29, 33, 34.

This new species of Upper Sonoran Zone is closely similar in coloration to *S. albolineata* (Thomas) of the Sahuaro Desert regions of Arizona and Sonora but differs in its more robust form and black caudal tibiae with yellow black-



Figs. 28-32. *Schistocerca* spp.—28. *S. americana* female, Presidio, Texas; 29. *S. chinatiensis* type female, canyon three miles west of Shafter (Chinati Mts.); 30. *S. lineata* female, Davis Mts., elevation 8000-9000 feet; 31. *S. shoshone* male, Presidio, Texas; 32. *S. vaga* female, Presidio, Texas.

tipped spines; in *albolineata* the caudal tibiae are coral red with red black-tipped spines. The form of the new species is more closely similar to *S. lineata* Scudder of the Transition Zone but differs strikingly from that species, based on Davis Mountain specimens, in its smaller size, brighter coloration with lemon yellow markings on the sides of the pronotum and thoracic pleurites which are lacking in *lineata,* by the more cristate form of the pronotum and the black fasciations on the caudal femora and the more extensive black of the caudal tibiae. Close resemblance is also shown to *S. insignis* described from Guadalajara, Jalisco, Mexico, by Hebard in 1932, but the size is slightly smaller, the pronotum more cristate and the markings of the caudal femora much more conspicuous with its two black dorsal fasciae and the ivory black herringbone design on the outer pagina of the caudal femora.

Type: ♀, Chinati Mountains, Presidio County, Texas, 4 miles west of the mining town of Shafter, 19, X, 46 (taken in dense Lower Sonoran vegetation of a canyon where some water was present). Measurements of type in millimeters: total length from head to apex of tegmen 51.5, to apex of ovipositor jaw 48.0, to apex of caudal femur 45.0; pronotum 10.5; tegmen 40.0 x 7.0; caudal femur 25.0; caudal tibiae 23.0; antennae 19.0. Type in the Tinkham Collection.

Description: size medium, build moderately robust and form typical of the genus. Fastigium noticeably impressed and in profile gently sloping in front to round evenly into the frontal costa. Pronotal crest, seen in profile, gently but distinctly arcuate, cut exactly in the middle by the principal sulcus, the prozonal section cut by two additional sulci, the first or cephalad one in the center of the prozona. Lateral lobes of the pronotum as broad as deep. Prosternal spine, small, conical with blunt apex. Apices of caudal femora almost reaching to the tip of the ovipositor which is only slightly surpassed by the apices of the tegmina.

Coloration: general coloration of head and thorax shining black; abdomen dark olive brown; yellow patches laterally on the head and thorax and a yellow stripe extending dorsally from the fastigum to near the apex of the closed tegmina. Caudal femora conspicuously bifasciate with black above, knees black and outer pagina ivory white marked with herringbone design of ivory black.

Head with fasitigium and occiput black with a moderately broad, median stripe of yellow; face blackish, clypeus and labrum greenish black, palpi yellow. Sides of the head caudad of the lateral carina dull yellow with an oblique subocular band of black. Antennae yellow.

Pronotum with prozona shining black; metazona deep greenish black, with the yellow dorsal stripe of the head continuous along the pronotal crest. Central portions of the lateral lobes of the prozona with a transverse chrome yellow patch; metazona with minute scattered flecks of yellow. Meso- and metapleurites, dark greenish black with a large vertical rectangular bar of chrome yellow on the meso-epimeron and the central portions of the metepimeron with some yellow. Thoracic sternites dark olive. Abdomen dark olive with three small black dots along the posterior margin of each abdominal pleurite. Tegmina greenish black at base and grading to dull reddish brown apically.

Forelegs shining black dorsally, dark olive ventrally. Middle legs with the mesofemora greenish black dorsally, olive brown laterally and ventrally with

some spots of pale yellowish white along the outer pagina; mesotibiae greenish black dorsally, yellowish laterally and ventrally; tarsi similarly marked. Caudal femora dull yellowish green above, chrome yellowish pregenicularly with two broad black cross bands, the proximal about 3/7 the distance from the base, the second 5/7 and contiguous with the pregenicular yellow. Genicular arches shining black with the ventro-lateral lobes yellow exteriorly and whitish-yellow interiorly. Dorsal femoral crest black at base with a few scattered black dots proximally. Outer pagina pearly white, with the musculatural sutures shining ivory black tinging the white of the upper half with a shade of gray. Lower and internal faces of the caudal femora whitish. Caudal tibiae shining ivory black, streaked with whitish along the ventral ridge (dorsal in closed leg) and with the tibial spines lemon yellow tipped with black. Caudal tarsus dull greenish black.

Paratype: 1 ♀, same data as the type. Form and coloration very closely similar to the type; the only difference noted being in the pronotum where the length of the metazona is only a shade longer than the prozonal portion. Measurements of the ♀ paratype

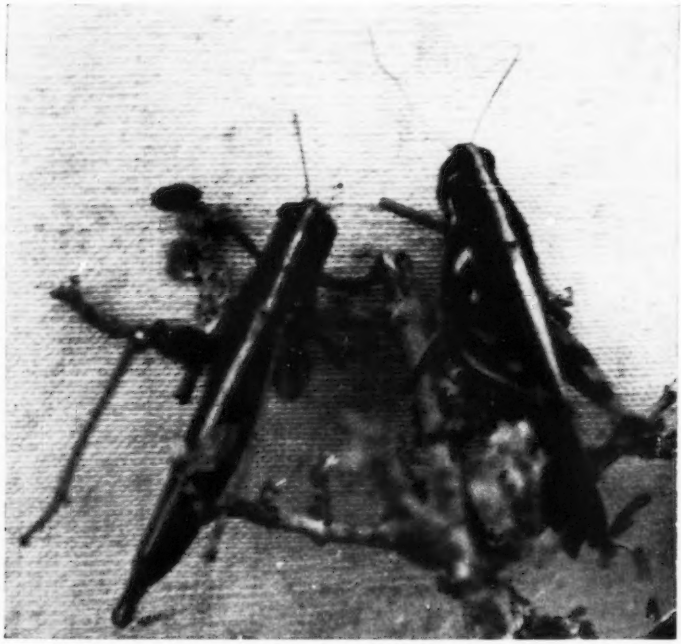


Fig. 33. *Schistocerca* spp.—*S. chinatiensis* Tinkham, living type female (right). Note bright yellow markings on the blackish coloration of thorax and the black fasciae on the caudal femora. *S. shoshone* (phase) female, from chaparral zone at Yarnell, Arizona, on host plant, *Caenothus Greggii* (left).

in millimeters: length to tip of tegmina 52.5, length to apex of ovipositor jaws 49.0, length to apex of caudal femur 45.0; pronotum 10.5; tegmen 41.0 x 7.2; caudal femur 25.0; caudal tibia 23.0; antenna 19.0. Paratype in the Tinkham Collection.

Faunal Designation: Schistocerca chinatiensis Tinkham, was found inhabiting the dense vegetation of a watered Chinati Mountain canyon, some four miles west of Shafter, on the lower edge of the Upper Sonoran Zone and practically in Lower Sonoran environments. It was there very rare for continued search revealed only the two females and no males. This new species is believed to be indigenous to the Chinati Mountains and certain undefined areas of northeastern Mexico and due to its restricted range is placed as a member of the Chihuahuan Upper Sonoran fauna. Not until a careful revision of the

Fig. 34.—Type locality of *Schistocerca chinatiensis* Tinkham, a wild rugged canyon dense with vegetation, about four miles west of Shafter, Texas, in the Chinati Mts.

genus *Schistocerca,* for southwestern United States and Mexico, has been made can the exact relationship of the new species be established. It may prove eventually to be a race of the Mexican *S. insignis,* or of the American *S. lineata* but for the present its striking coloration and form is worthy of specific recognition.

* NETROSOMA NIGROPLEURA Scudder

Presidio, 5, IX, 28, 1 ♂, 2 ♀♀ (small rocky ravine on edge of first mesa). Chinati Mts., (1), 29, X, 28, 1 ♀; 4, VIII, 29, 1 ♂; 18, X, 46, 5 ♂♂, 1 ♀. Chinati Mts., 16, IX, 29, 1 ♂; 11, X, 29, 1 ♀. 5 miles south of Chisos-Boquillas Road Junction, Brewster Co., 28, X, 46, 1 ♀.

This species was described by Scudder, in 1897, from Lerdo, Durango, Mexico and has been recorded from Jaral, Coahuila. The male is the smallest cyrtacanthacrid of the entire region and possesses great saltatorial powers. It is whitish gray suffused with a tint of salmon on the abdomen and with a broad, dark brownish, post-ocular stripe on head, thorax and base of the abdomen. The females are much larger and violet gray in color, and measure 22

mm. in length as compared to 12 mm. for the body length of the male. The caudal tibiae are coral pink in both sexes.

N. nigropleura is an endogene of the Chihuahuan Lower Sonoran fauna and is a very rare species occurring only in certain localities. Its diminutive size and secretive habits of the female make this species easily overlooked. This is the first Texas record and the first for the United States as far as I am able to ascertain from the literature.

* PHILOCLEON NIGROVITTATA (Stål)

Ten miles east of Marathon, Brewster Co., 15, VIII, 40, 1 ♂, 1 ♀. Dead Horse Mts., Brewster Co., 23, X, 46, 1 ♂, 1 ♀ (in clumps of *Euphorbia antisiphilitica;* very rare).

This small species is distinguished by having head and thorax creamy yellow with a dark brown post-ocular stripe that diverges strongly to cover the shoulders of the pronotum and remainder of the thoracic pleurite, leaving a narrow yellow median stripe running from head to abdomen. There is also band of yellow bordering the posterior lobes of the pronotum. The caudal femora are bifasciate on the outer pagina and the caudal tibiae are bluish green with orange pink at their bases. The tegmina are narrowly elliptical and a brownish stripe extends below the eye along the lateral areas of the face.

This interesting species is commoner in the states of Tamaulipas and Coahuila and only a narrow arm of its distribution extends into the United States along the eastern edge of the Big Bend Region. In its distribution it is similar to the giant dagger, *Yucca carnerosana* which invades the United States *via* the Dead Horse Mountains.

P. nigrovittata is a member of the Tamaulipan Semi-desert Bushland entering the Big Bend Region only along its southeastern border. These records appear to be the first for Texas and perhaps the first for the United States.

PHAEDROTETTIX DUMICOLA PALMERI (Scudder)

Chinati Mts., (1), 29, X, 28, 1 ♂, 2 ♀♀; 4, VIII, 29, 5 ♂♂, 3 ♀♀, 1 juv. ♂; 18, X, 26, 2 ♂♂, 2 ♀♀. Chinati Mts., 16, IX, 29, 1 ♂; 12, X, 29, 1 ♀; 6, VII, 30, 1 ♀. North slope Blue Mt., Chinatis, 27, IX, 31, 4 ♂♂, 2 ♀♀ (elev. 5500-6000 feet). Cox's Ranch, south base of Mt. Livermore, Davis Mts., 29, IX, 31, 1 ♂, 2 ♀♀; 3 ♂♂, 5 ♀♀ (Univ. of Minn. Cln.). Chinati Mts., (7), 27, IX, 31, 2 ♂♂, 3 ♀♀. Wilson's Ranch, west base of Mt. Emory, Chisos Mts., 17, VII, 30, 5 ♂♂, 3 ♀♀ (Hebard and Tinkham Clns.). Pass at head of Green Gulch, Chisos Mts., elev. 6600 ft., 24, X, 46, 3 ♀♀. Dead Horse Mts., Brewster Co., 24, X, 46, 1 ♂ (rare).

This small beautifully-marked species is readily distinguished by its dark brown color, brown post-ocular band and greenish caudal tibiae. The small tegminal pads are ellipsoidal in form. It was fairly abundant on the northern slopes of Blue Mountain, second highest peak in the Chinatis at elevations ranging from 5500 to 6500 feet; while in the Davis Range its altitudinal zonation extended from about 6000 to 7500 feet. In the Chisos the species was not common.

This species is an endogene of the Chihuahuan Upper Sonoran fauna inhabiting an altitudinal zone ranging from 4500 to 7500 feet. The distribution

of this species extends from the Big Bend Region south throughout the mountain systems of northeastern Mexico.

PHAULOTETTIX EURYCERCUS Hebard

Chinati Mts., (1), 30, IX, 28, 1 ♂, 29, X, 29, 1 ♀; 4, VIII, 29, 1 ♂; 23, IX, 31, 1 ♀; 18, X, 46, 1 ♂. Chinati Mts., 12, IX, 29, 1 ♂; 16, IX, 29, 1 ♂, 2 ♀♀; 22, IX, 29, 2 ♂♂. 10 miles east of Marathon, Brewster Co., 15, VIII, 40, 1 teneral ♂. Mesa 5 miles north of Hot Springs near Boquillas, Brewster Co., 28, X, 46, 6 ♂♂, 2 ♀♀, 2 ♂♂ nymphs (series very small; feeding on *Leucophyllum frutescens*). Dead Horse Mts., 24, X, 46, 3 ♂♂, 3 ♀♀.

This, the sotol grasshopper, is one of the rare species of the Region. Although only slightly smaller than *Agroecotettix m. crypsidomus* it resembles that species very closely but can be separated by the presence of tegmina that are narrow elliptical and not circular as in *Agroecotettix*. In the Chinati Mountain area *Phaulotettix* has only been found in clumps of the sotol bush, *Dasylirion texanum*, and when danger threatens or an attempt is made to capture them they simply drop down into the heart of the spiny plant where they are most difficult to retrieve. In this habit they resemble many beetles such as the sotol borers, *Thrincopyge alacris* and *ambiens* (Buprestidae) and the Agave shot-hole borers, *Zygops suffusus* and *seminiveus* (Curculionidae) and others, all of which drop and "play possum" when an attempt is made to capture them. On the mesas north of the Hot Springs near Boquillas and southeast of the Chisos Mountains, the writer found this species feeding on the silvery leaved *Leucophyllum frutescens* but these specimens were all very small. In 1946, *Phaulotettix* was much rarer in the Chinatis than in the years 1928 to 1931; only one male specimen was collected in four days of collecting.

Hebard described this species, in 1917, and selected Laguna del Gato in Hidalgo County, Texas, as the type locality. *P. eurycercus* is closely related to the Mexican *P. compressus* Scudder and belongs to the Chihuahuan Lower Sonoran fauna. In Mexico, the sotol grasshopper is found in Tamaulipas, Nuevo Leon and Coahuila.

AGROECOTETTIX MODESTUS CRYPSIDOMUS Hebard

Chinati Mts., (1), 30, IX, 28, 1 ♂, 4 ♀♀; 4, VIII, 29, 3 ♂♂, 3 ♀♀; 18, X, 46, 6 ♂♂, 3 ♀♀. Chinati Mts., 9, IX, 29, 2 ♂♂; 6, VII, 30, 1 ♂. North base of Blue Mt., Chinatis, 27, IX, 31, 7 ♂♂, 4 ♀♀; 5 ♂♂, 4 ♀♀ (Univ. of Minn. Cln.; elev. 5500-6000 ft.). Cox ranch, south base of Mt. Livermore, Davis Mts., 29, IX, 31, 2 ♂♂, 1 ♀; 1 ♀ (Univ. Minn. Cln.; elev. 6000-7500 ft.). Wilson's ranch, west base Mt. Emory, Chisos Mts., 17, VII, 30, 3 ♂♂, 3 ♀♀ (Hebard Cln.). 10 miles east of Keat, Jeff Davis Co., 14, IX, 40, 1 ♂, 1 ♀. 20 miles southwest of Balmorrhea, mouth of Lower Limpia Canyon, 12, X, 46, 1 ♀. 3 miles west of Shafter, Chinati Mts., 19, X, 46, 3 ♀♀. Pass at top of Green Gulch, Chisos Mts., 24, X, 46, 1 ♀ (elev. 6600 ft.). Chisos Basin, south base Pulliam Bluff, elev. 6600 ft., 25, X, 46, 1 ♂, 3 ♀♀. Dead Horse Mts., 24, X, 46, 4 ♀♀. 5 miles south of Chisos-Boquillas Road Junction, 28, X, 46, 1 ♀.

This species has practically the same altitudinal zonation as *Phaedrotettix* ranging from 4500 to 7500 feet elevation. In Lower Sonoran habitats it is commoner than *Phaulotettix* dwelling in clumps of desert shrubbery such as lechuguilla, skeleton weed, sotol and other desert shrubs.

This handsome, medium-sized species was described by Morgan Hebard,

in 1922, with Marathon, Brewster County, Texas, as the type locality. He also records it from the Quitman Mts., near El Paso. *Agroecotettix* ranges from southwestern Texas south into northeastern Mexico. It is a member of the Chihuahuan Upper Sonoran fauna.

CAMPLYCANTHA OLIVACEA VIVAX (Scudder)

20 miles north of Chisos Mts., Brewster Co., 18, VII, 30, 1 ♂ (Hebard Cli:). 5 miles east of Sanderson, Terrell Co., 15, VIII, 40, 3 ♂♂, 3 ♀♀ (common on *Flourensia*). North end of Davis Mts., 10 miles east of Kent, Jeff Davis Co., 14, IX, 40. 20 miles southwest Balmorrhea, mouth of Lower Limpia Canyon, Jeff Davis Co., 12, X, 46, 1 ♂, 1 ♀ (in *Baccharis along* banks of stream). 6 miles northeast of Marfa, Presidio Co., 13, X, 46, 2 ♀♀ (*Flourensia*). 10 miles south of Wilna, New Mexico, 3, XI, 46, 10 ♂♂, 8 ♀♀ (common on *Flourensia*).

C. vegana Sc. and Ckll., described from Las Vegas, New Mexico is a synonym.

The distribution of this grasshopper closely follows that of its host plant *Flourensia cernua* which north of the Davis Range and from the Pecos west to southeastern Arizona is co-dominant with creosote to form the Pecos subdesert region of the Great Chihuahuan Desert. Intrusions of *Flourensia* break through valleys west of the Davis Range into the region north of Valentine and south of Van Horn. *Flourensia* is common north of the Chisos but in the southern part of Presidio it is very rare. This unusual distribution of *Flourensia* accounts for the lack of records of *Camplyacantha* in the southern part of Presidio County which is dominated with the sotol-lechuguilla type of vegetation characteristic of the Coahuila Desert, the second subtype of the Great Chihuahuan Desert. This type follows up the Rio Grande to the Hueco and Franklin Mountains. The Chisos Mountains, east of the Chinatis by at least 100 miles, and influenced strongly by the Pecos Valley, has faunal elements not found in the Chinatis. These elements are typical of central Texas, whereas the Chinatis portray a very strong Mexican influence with a fauna typical of Durango and Coahuila.

Camplyacantha o. vivax has an extensive range from the Pecos River to the Deming area of New Mexico and may some day be found in eastern Arizona. It occurs north into southeastern Colorado and adjacent parts of Kansas and western Texas. East of the Pecos, the race *lampronota* Rehn and Hebard, replaces *vivax*. *Vivax* is a member of the Chihuahuan Lower Sonoran fauna.

AEOLOPLUS ELEGANS Scudder

An arroyo valley 7 miles north of Presidio, 23, VI, 29, 1 ♂, Indio, Presidio Co., 6, VI, 30, 3 ♂♂, 1♀ (*Sarcobatus vermiculatus*).

The Indio specimens were taken in associated clumps of *Sarcobatus vermiculatus* and joint cactus, probably *Opuntia leptocaulis*. When avoiding capture the hoppers jumped down into the center of the dense spiny masses where they concealed themselves behind stems and twigs and were almost impossible to locate and capture. Their habitat was on an adobe flat adjacent to the habitat of the rare and beautiful *Anconia hebardi*. This species is an early summer form.

Aeoloplus elegans is a member of the Chihuahuan Lower Sonoran fauna

and is confined to southwestern Texas and southern New Mexico but its range at present is poorly defined. The type locality is Las Cruces, New Mexico.

HESPEROTETTIX VIRIDIS VIRIDIS (Thomas)

Presidio, June, 1929, 1 ♀ (Scout Lloyd Johnson). Marfa, 22, VI, 30, 2 ♂♂, 2 ♀♀. Near Guadalupe Peak, Texas, 19, VII, 30, 1 ♀ (elev. c. 5000 ft.).

The races of *H. viridis* are numerous. In eastern parts of the United States is to be found *brevipennis* Thomas, in northern parts *pratensis* (Scudder), in the west *nevadensis* Morse and in the southwest *viridis* (Thomas). Host plants include, burrowweed, snakeweed and desert broom.

The range of *H. v. viridis* extends from eastern Colorado and western Oklahoma, Kansas and Nebraska southwest into the desert regions of southwestern Texas and Arizona. It is a member of the Upper Sonoran Faunal Zone.

MELANOPLUS (Stål)

The genus *Melanoplus* is the largest of all Nearctic genera comprising several hundreds of species which often so closely resemble one another that only a taxonomist can separate them. The most injurious species in North America belong to this genus.

KEY TO THE SPECIES OF MELANOPLUS OF TRANS-PECOS TEXAS

1. Brachypterous species with tegmina equal to or only slightly greater than the length of the pronotum and never reaching to apex of abdomen; usually small species 2
   Fully winged species with the tegmina equalling or surpassing the apex of the abdomen; medium or large species 4
2. Tegmina lanceolate; cerci with bulbous base and small pointed apex; caudal tibiae blue ..... *lakinus* (Scudder)
   Tegmina oval or elliptical 3
3. Tegmina oval-elliptical in form; cerci very long and slender, slightly broadened apically and about the same length as the supra-anal plate; caudal tibiae glaucous ..... *aridus* Scudder
   Tegmina oval; cerci slender but not noticeably broadened apically and shorter than the length of the supra-anal plate; caudal tibiae bluish ..... *desultorius* Rehn
4. Species of large size over one and one-quarter inches 5
   Species of medium size under one and one-quarter inches 7
5. Body coloration bluish green; caudal tibiae coral red ..... *thomasi*
   Body yellowish; caudal tibiae yellowish 6
6. Cerci greatly expanded on the upper two-thirds into a large rounded lobe and with a lobate projection on the apical third of the lower margin; caudal femora yellowish with two broad transverse bands with forward projecting spurs; caudal tibiae primrose yellow ..... *eumera*
   Cerci very large and distinctly boot-shaped, the heel on the lower margin; caudal femora yellowish with a row of black herringbone markings on the outer pagina; caudal tibiae yellow with post-basal black annulus; some males black ..... *differentialis*
7. Caudal tibiae bluish green or glaucous 8
   Caudal tibiae reddish 13
8. Cerci large, flabellate, broadest in the middle tapering rapidly to rounded apex ..... *occidentalis*
   Cerci not broadest in middle but tapering from base 9

9. Furculae very large and broad, at least half the length of the supra-anal plate 10
Furculae never large and broad but slender 11

10. Body, tegmina and legs wholly green; pagina of caudal femora not banded, caudal tibiae green; body form medium-slender; cerci slender; furculae attingent for most their length ..... *herbaceus*
Body color grayish brown somewhat tinged with greenish; tegmina pale glaucous, slender, and far surpassing the apex of the abdomen; caudal femora brownish yellow tinged with plumbeous; caudal tibiae bluish green; tip of male abdomen upturned; cerci long and slender; body long and slender ..... *bowditchi-flavidus* group

11. Furculae long, tapering to acuminate apices from broad bases; cerci with incurved rounded apex ..... *arizonae*
Furculae small in size 12

12. Cerci uniformly broad throughout, subreniform, with the apical portion upturned and broadly rounded; general color yellowish brown with a broad black postocular band on head and pronotum; tegmina barely surpassing the apex of the abdomen; caudal femora bifasciate on the superior surface with pagina plain; caudal tibiae glaucous ..... *glaucipes*
Body color more brightly colored than usual for the genus with green and red on head, pronotum and caudal femora; caudal femora deep blue green with red on inferior keel and on the inner surface; caudal tibiae glaucous; size medium and rather robust for the genus; cerci short tapering to acute apex ..... *regalis*

13. Furculae present as two widely separated minute denticulations; caudal tibiae always red; general color dark brown; form moderately large and robust; caudal femora bifasciate ..... *gladstoni*
Furculae one-third to one-half the length of supra-anal plate; form smaller and slenderer 14

14. Furculae slender, tapering, with the apices strongly divergent and about one-third the length of the plate; apex of male subgenital plate produced and decidedly notched in the center; caudal tibiae usually red ..... *mexicanus*
Furculae slender, tapering, and parallel, about one-half the length of the plate; apex of the male subgenital plate low and broadly convex; caudal tibiae usually red ..... *femur-rubrum*

MELANOPLUS ARIDUS Scudder

Chinati Mts., near Shafter, 30, IX, 28, 1 ♂, 3♀♀. Chinati Mts., (3), 16, IX, 29, 1 ♂; Chinati Mts., (1), 12, X, 29, 6 ♂♂, 3 ♀♀; 19, X, 29, 3 ♂♂, 2 ♀♀. Chinati Mts., (7), 1 ♀; 1 ♂, 2 ♀♀ (Univ. of Minn. Cln.).

Melanoplus aridus is one of the smallest and commonest species of the southwest especially in Arizona. In Texas it is not as abundant. Its altitudinal range is very great, extending from the desert at low elevations to pine-clothed mountain ridges at 9300 feet as in the Magdalena Mountains of New Mexico and many ranges in Arizona.

In the Chinati Mountains one of the favorite host plants was a species of *Dalea* whose silvery gray-green leaves it closely resembled. *Aridus* is as much at home in the Lower Sonoran Zone as in the Transition.

†† MELANOPLUS DESULTORIUS Rehn

Marfa, 5, X, 29, 2 ♂♂, 1 ♀; 22, VI, 30, 1 ♂, 1 ♀; 29, VI, 30, 1 ♀. South base of Mt. Livermore, Davis Mts., 29, IX, 31, 1 ♀.

This species closely resembles *M. aridus* but is larger with more ovoid teg-

mina and yellowish green coloration. The caudal tibiae are a deep bluish color. The host plants are burrowweeds, snakeweeds and related plants. This is the first Texas record of a grasshopper quite common on the grasslands of southeastern Arizona. It is a member of the Southwestern Grasslands fauna of the Upper Sonoran Zone; its range extending from southwestern Texas to southeastern Arizona and south into Sonora, Mexico.

MELANOPLUS LAKINUS (Scudder)

Chinati Mts., (7), 27, IX, 31, 3 ♂♂ (size very small). Marfa, 4 X, 29, 3 ♂♂, 4 ♀♀. Davis Mts., 22, X, 28, 1 ♂, 4 ♀♀. Cox's Ranch, south base of Mt. Livermore, Davis Mts., 29, IX, 31, 1 ♀; 1 ♂, 1 ♀ (Univ. of Minn. Cln.). 7 miles south of Van Horn, 31, X, 46, 1 ♂. 3 miles east Alpine, 22, X, 46, 3 ♂♂. Chisos Basin, Chisos Mts., 24, X, 46, 2 ♂♂, 2 ♀♀.

M. marculentus Sc., and *M. sonorae* Sc., are synonyms.

M. lakinus is easily recognized by its small size, lanceolate tegminal pads and the peculiar shape of the male cerci. It is an inhabitant of the Upper Sonoran Zone but its range is slightly more extensive northward than most members of the Southwestern Grasslands fauna as it occurs north to Capa, South Dakota. It is also found in eastern Colorado and western Kansas thence south to the Big Bend grassland areas and west across New Mexico to southeastern Arizona and south into Sonora.

MELANOPLUS THOMASI Scudder

Marfa, 5, X, 29, 1 ♀, 1 ♂ (Univ. of Minn. Cln.). Ft. Davis, 13, X, 46, 2 ♂♂, 1 ♀.

M. thomasi in its striking bluish green color and red caudal tibiae is one of the more uncommon species of southwestern Texas. The type male was described from Lerdo, Durango, Mexico, but the range of this species is as yet poorly defined. Its range extends from the grasslands of the Big Bend west to the San Pedro Valley in southeastern Arizona, north to central New Mexico and south to the Mexican states of Sonora, Sinaloa, and Durango. In Arizona the favorite food plant is the stinking *Verbesina enceloides*. Like *M. differentialis* the large egg pods containing up to 80 eggs are hid in large clumps of grass. *M. thomasi* is a member of the Southwestern Grasslands fauna of the Upper Sonoran Zone.

MELANOPLUS EUMERA Hebard

Chinati Mts., 22, IX, 29, 2 ♂♂, 1 ♀ (elev. c. 5000 ft.). Base of Blue Mt., Chinati Mts., 27, IX, 31, 6 ♂♂, 5 ♀♀ (elev. 5000-5500 ft.). Chinatis (3), 19, X, 46, 3 ♂♂, 2 ♀♀. Paisano, Presidio Co., 22, VI, 29, 1 ♀ (Hebard Cln.). Cox's Ranch, south base of Mt. Livermore, Davis Mts., 29, IX, 31, 6 ♂♂, 5 ♀♀; 3 ♂♂, 2 ♀♀ (Univ. of Minn. Cln.). Lost Mine Peak, Chisos Mts., Sept. 6, 1912, 1 ♂ paratype (Rehn and Hebard: Tinkham Cln.). Canyon behind Pulliam Bluff, Chisos Mts., Sept. 7, 1912, 1 ♀ paratype (Rehn and Hebard; Tinkham Cln.). Green Gulch, north side Chisos Mts., 24, X, 46, 7 ♂♂. Pass at head of Green Gulch, elev. 6600 ft., 24, X, 46, 1 ♂, 1 ♀. Chisos Basin, south base Pulliam Bluff, 25, X, 46, elev. 6000 ft., 1 ♂, 3 ♀♀.

In 1920, Hebard described *M. eumera* and selected Lost Mine Peak, in the

Chisos Mountains as the type locality. This species appears to show nearest relationship with *M. ponderosa* (Sc.) supplanting that species in the arid regions west of the Pecos River. It is a beautifully marked species of large size that can be easily recognized by its yellowish brown coloration with heavy black post-ocular band and heavy dark fasciations on the caudal femora. The caudal tibiae are primrose yellow.

M. eumera is found only above 5000 feet in certain valleys on the northern slopes of the Chinati Mountains and on the northern slopes of Blue Mountain (locality no. 7) where it is fairly common. Its altitudinal range is approximately 5000 to 7000 feet. *M. eumera* is a member of the Chihuahuan Upper Sonoran fauna.

MELANOPLUS DIFFERENTIALIS NIGRICANS Roberts

Presidio, 20, X, 28, 1 ♀. Ft. Davis, 13, X, 46, 1 ♀. Spring 20 miles south of Marathon, Brewster Co., 23, X, 46, 1 ♂.

A single specimen only was encountered in the Rio Grande Valley during two years collecting. Hebard, in 1909, reports it as fairly swarming on irrigated land at El Paso and it apparently just survives at Presidio due to agricultural conditions.

M. differentialis nigricans whose racial status Roberts decided in 1942, is the western subspecies whose eastern limits more or less follow the eastern boundaries of Texas, Oklahoma and Kansas to the Missouri, thence northwestern Iowa and western Minnesota to southwestern North Dakota. Its occurrence in Montana and Wyoming is very rare but it is common in Colorado and a pest in the cultivated valleys of New Mexico and Arizona. South in Mexico it is found in many Mexican states.

This very destructive species is interesting because of the melanism that occurs chiefly in the male sex. The differential grasshopper is a member of the Upper Sonoran Zone and survives in Lower Sonoran habitats where agriculture and irrigation exists.

MELANOPLUS OCCIDENTALIS OCCIDENTALIS (Thomas)

Marfa, 5, X, 29, 1 ♂; 22, VI, 30, 5 ♂♂, 3 ♀♀; 1 ♂ (Univ. of Minn. Cln.). Davis Mts., 29, IX, 31, 1 ♀ (Univ. of Minn. Cln.).

This species is easily recognized by the large cerci which are greatly expanded from the base to the middle and then suddenly contracted to the rounded apex. This hopper is an early season species that has a wide distribution but is nowhere common and seldom of economic importance. Its range extends from the southern prairie provinces of western Canada south as far as the Mexican state of Zacatecas. Ranging east of the Rockies its eastern limits are west central Minnesota, southwestern South Dakota, western Nebraska and Kansas. It is also found in Utah, Idaho and southern British Columbia. In the southwest its range extends from the grasslands of the Big Bend Region to the grassland areas of Arizona. The flabellifer grasshopper belongs to the Upper Sonoran Faunal Zone.

MELANOPLUS HERBACEUS Bruner.

As El Paso, Texas, is the type locality for this species it seems reasonable to suppose that it should be found in the nearby Big Bend Region. Its range extends from the Rio Grande Valley, in New Mexico west to Arizona and thence to southwestern Utah and southeastern Nevada. One of its favorite food plants is the arrowweed that grows along the margins of streams in the Southwest. This species belongs to the Lower Sonoran Faunal Zone.

MELANOPLUS GLADSTONI Scudder

Marfa, 22, X, 28, 3 ♂♂, 1 ♀; 1 ♂, 1 ♀ (Univ. of Minn. Cln.); 5, X, 29, 1 ♀. Prairies 10 miles north of Marfa, 28, IX, 31, 1 ♂. Cox's Ranch, south base of Mt. Livermore, Davis Mts., 29, IX, 31, 1 ♀.

Synonyms: M. conspersus Sc., *M. compactus* Sc., *M. corpulentus* Sc., *M. bicoloratus* Sc.

The Marfa specimens are fully twice the size of *gladstoni* taken by the writer in southern Alberta and because of their large size were described as *corpulentus* by Scudder. *M. bicoloratus* represents material of *gladstoni* from the mountainous regions of southern Colorado and New Mexico in which the wings are usually long and well developed.

The distribution of *M. gladstoni* in North America is far reaching, extending from the Canadian prairie provinces south to the Mexican highlands in the states of Sonora, San Luis Potosi, Zacatecas, Morelos, Jalisco and Districto Federal. East of the Rockies its eastern limits are found in western Minnesota, northwestern Iowa to western Kansas. From northern Texas it ranges throughout New Mexico to the grasslands of the Big Bend and west to northern Arizona.

M. gladstone is an inhabitant of the Upper Sonoran and Transitional Faunal Zones.

MELANOPLUS REGALIS (Dodge)

Davis Mts., 22, X, 28, 2 ♀♀. Marfa, 22, VI, 30, 2 ♂♂. Prairies 10 miles north of Marfa, 28, IX, 31, 1 ♀.

Synonyms: M. picturatus Br., and *Acoloplus crassus* Sc. and Ckll.

M. regalis is one of the most beautifully marked species of the genus *Melanoplus*, easily recognized by its moderate and robust size, with green and reddish markings on its body and with the caudal tibiae green. *M. picturatus* synonymized by Hebard, in 1929, represents the brightly-colored form from Arizona and northern Mexico. As a member of the Southwestern Grasslands fauna of the Upper Sonoran Faunal Zone, the range of *regalis* extends from grasslands of the Big Bend west to southeastern Arizona, south in Mexico to Chihuahua, San Luis Potosi and Jalisco, and north to eastern Colorado, southwestern Kansas and northern Texas.

It is possible that *Melanoplus femur-rubrum femur-rubrum* (De Geer) which has a very extensive distribution on the North American Continent, will be found at high elevations in the Davis Mts., as Rehn and Hebard (1909) report it from El Paso.

MELANOPLUS MEXICANUS MEXICANUS (Saussure)

This, the Lesser Migratory Locust and the most injurious grasshopper in America, which was previously known as *M. atlanis* is dispersed over the greater part of the continent. Rehn and Hebard found it in El Paso, in 1909, and it may eventually be found at higher elevations in the Davis Mountains.

MELANOPLUS ARIZONAE Scudder

Marfa, 22, X, 38, 1 ♂; 5, X, 29, 1 ♀ (Univ. of Minn. Cln.); 22, VI, 30, 3 ♂♂; 28, IX, 31, 1 ♀.

This species closely resembles *M. mexicanus* in size and coloration but can be distinguished from that species by the unnotched apex of the male's subgenital plate. As a member of the Southwestern Grasslands fauna of the Upper Sonoran its range extends typically from eastern Colorado and western Kansas southwest through New Mexico to the grasslands of Arizona and those of the Big Bend. In Mexico it ranges south to Sinaloa, Durango, Coahuila and Tamaulipas.

MELANOPLUS FLAVIDUS ELONGATUS Scudder

15 miles south Marathon, Brewster Co., Texas, 18, VII, 30, 1 ♀ (Hebard, Tinkham Cln.).

Hebard identifies this specimen with the statement "not certain." The status of many closely related species and races of *M. flavidus*, *M. bowditchi* and *M. cinereus* is at present quite uncertain. The range of *M. f. elongatus* is largely undefined. It is the southwestern race of the species which intergrades with the northern nominal race in the region of northern Texas and southwestern Kansas.

MELANOPLUS BOWDITCH PROPINQUUS Scudder

This species identified by Mr. Morgan Hebard with a query is a fairly common species in the cottonfields of the Rio Grande Valley. Little is known at present concerning the range of the various southwestern forms of this complex group of the genus *Melanoplus*. At present the name is listed although the exact status is uncertain.

MELANOPLUS GLAUCIPES (Scudder)

Presidio, 15, VIII, 29, 1 ♀. 15 miles south of Marathon, Brewster Co., Texas, 18, VII, 30, 1 ♀. Eastland Co., Texas, 11-14, VI, 21, 3 ♂♂, 1 ♀ (Grace Wiley; Univ. of Minn. Cln.). 3 miles south, Malaga, N. Mex., 12, X, 46, 1 ♂. 20 miles southwest Balmorrhea, 12, X, 46, 1 ♂.

The range of *M. glaucipes* is from the Rio Grande Valley in New Mexico east to central Texas and north to southeastern Colorado and western Kansas. It is a fairly common species in central Texas but occurs sparingly in the Southwest. In Mexico its range extends to Durango.

PHOTALIOTES NEBRASCENSIS (Thomas)

Davis Mts., 22, X, 28, 1 ♀. Marfa, 5, X, 29, 1 ♂, 1 ♀. Cox Ranch, south base of Mt. Livermore, Davis Mts., 29, IX, 31, 1 ♀. Marathon, Brewster Co., Sept. 12-13, 1912, 1 ♂ (Rehn and Hebard, 3900-4160 ft.; Tinkham Cln.). 20 miles southwest

Balmorrhea, Jeff Davis Co., 12, X, 46, 1 ♂. Chisos Bason, south base Pulliam Bluff, elev. 6000 ft., 25, X, 46, 1, ♀.

Synonyms: Melanoplus phoetaliotiformis Sc., *M. autumnalis, M. harrisii* Morse, *M. sanguineocephalis* (La Munyon), *M. volucris* (Dodge).

This interesting species, known as the "Red-nosed Grasshopper" has an extensive distribution over the Great Plains. Its range extends from southern Alberta to northern Texas and east of the Rockies to eastern Minnesota, western Indiana and Illinois south through central Kansas and Oklahoma to Dallas, Texas, thence through New Mexico to southeastern Arizona and the Big Bend of Texas. In Mexico it is found south to Vera Cruz and Districto Federal. Its unusual form and shape and its variability with occasional cases of macropterism, largely accounts for the many synonyms that exist today. It is an uncommon species in the Big Bend and is encountered most frequently in the higher grasslands of the Davis Range. Its distribution appears to be mainly Transition in extent.

DACTYLOTUM VARIEGATUM Scudder

Shafter Mt., near Shafter, Presidio Co., 30, IX, 28, 9 ♂♂, 3 ♀♀. Chinati Mts., 8, IX, 29, 1 ♂; 16, IX, 29, 3 ♂♂; 23, IX, 29, 2 ♂♂, 7 ♀♀; 6, VII, 30, 1 ♀. North base of Blue Mt., Chinati Mts., (7), 27, IX, 31, 2 ♂♂, 1 ♀; 6 ♂♂ (Univ. of Minn. Cln.). Marathon, Brewster Co., Texas, Aug. 26-27, 1913, 2 ♀♀ (Rehn and Hebard; 3940-4160 feet elev.). 20 miles southwest of Balmorrhea, Jeff Davis Co., 12, X, 46, 1 ♂. 10 miles north of Marfa, Presidio Co., 13, X, 46, 1 ♂. 1 mile north of Bunton Flat, 29 miles n. of Presidio, 22, X, 46, 2 ♂♂. 3 miles east of Alpine, 22. X, 46, 2 ♂♂, 1 ♀. Dead Horse Mts., Brewster Co., 24, X, 46, 1 ♂ (rare). Chisos Basin, south base Pulliam Bluff, elev. 6000 ft., 25, X, 46, 3 ♂♂, 1 ♀ (rare).

Few acridids anywhere will surpass the beauty of this species which has been called the "Rainbow Grasshopper," the "Barberpole" and the "Colonel." Only *Taeniopoda eques* (Burm.) in its striking black colors with gold braid and rose wings approaches it in coloration. *D. variegatum* is, however, more regally robed in its royal purple washed with yellow and orange red and it cannot be mistaken for any other species in the Southwest. It has a northern relative *D. pictum* which is found only on the Great Plains.

The distribution of *D. variegatum* is at present poorly defined. It ranges from the Big Bend Region to Arizona where it is found west to the Baboquivari Mts. and north to the Sierra Anchas. In Mexico it is found in northern Sonoran and south to Casa Grande in Chihuahua. In its habitat preferences *variegatum* seems to occupy the ecotonic area between the Lower and Upper Sonoran Zones as it does not occur in the oak zone itself or out on the desert proper. Hence it is not typically Lower or Upper Sonoran.

The TETTIGONIIDAE

The members of the Tettigoniidae are a composite group of orthopterans known as katydids. The Phanerotropinae and Pseudophyllinae are the green leaflike katydids in which the female ovipositor is very short and strongly recurved with its margins serrate with teeth. This ovipositor is used to lay the flat oval eggs along the margins of leaves. The Decticinae have long or gently decurved or recurved sword-like ovipositors and their tegmina are very abbre-

viated although a few genera are fully winged. The green "Cone-headed Katydids" include the Copiphorinae of large size and the Conocephalinae of small size. Both these subfamilies have long straight or gently recurved ovipositors and the eggs are laid singly in the ground. Members of the decticid genera *Anabrus* and *Peranabrus* are very destructive in the northwestern states but Trans-Pecos Texas has no injurious members.

KEY TO THE SUBFAMILIES OF THE TETTIGONIIDAE OF TRANS-PECOS TEXAS

1. First two tarsal segments without lateral grooves; male subgenital plate produced caudad 2
   First two tarsal segments with lateral grooves; male subgenital plate small 3
2. Ovipositor abruptly recurved with margins serrate or toothed; tegmina usually long and slender (although abbreviate in *Dichopetala*) and not enclosing the abdomen; male subgenital plate produced briefly caudad and often recurved ..... PHANEROTROPINAE
   Ovipositor sword-like and gently recurved; tegmina large and enclosing the entire body; male subgenital plate straight and lengthily produced caudad ..... PSEUDOPHYLLINAE
3. Pronotum small; tegmina usually long and linear; fore tibiae spineless on the upper surface 4
   Pronotum large and broad, forming a shield protecting the base of the tegmina which are usually small brachypterous trilling pads, although fully winged in *Capnobotes;* fore tibiae with a short spine or spines on the dorsal surface ..... DECTICINAE
4. Vertex produced forward into a long or rounded cone broadest at the base; fore and middle legs spined beneath; size large ..... COPIPHORINAE
   Vertex terminating in a rounded tubercle, the base narrower than the middle; fore and middle legs not spined below; size small ..... CONOCEPHALINAE

PHANEROTROPINAE

This is the largest subfamily of katydids in southwestern Texas. With the exception of *Dichopetala* all are long-winged and in form closely resembling leaves in outline. The general color is green or grayish green and the size range is from small to medium large. The ova are oval in outline and flat and laid along or in the margins of leaves.

KEY TO THE GENERA OF THE PHANEROTROPINAE OF TRANS-PECOS TEXAS

1. Species of small size and long slender legs; tegmina and wings represented by small trilling pads ..... *Dichopetala* Bruner
   Species with tegmina well developed and elongate 2
2. Size small and body slender; legs very slender and tegmina long and uniformly narrow 3
   Size large and more robust; legs not as slender and tegmina long, usually broadened in the middle and tapering to a rounded apex 4
3. Species exceptionally slender; hind legs very long, delicate and slender; tegmina usually long and slender and surpassed by the wings to a variable extent; body color usually grayish green; tegmina and wings in females often abbreviate in certain species ..... *Arethaea* Stål
   Species not as slenderly built; tegmina and wings equally as long in females as in males and far surpassing apex of the abdomen; legs not exceptionally slender; tegmina usually barred with whitish diagonal stripes on greenish background; size small ..... *Insara* Walker

4. Tegmina distinctly broadened in the middle; vertex much broader than the first antennal segment 5

Tegmina long and nearly equal in breadth throughout; vertex of about the same width as the first antennal segment ..... *Scudderia* Stål

5. Caudal femora much shorter than the length of the tegmina; female ovipositor short and abruptly turned upwards; size moderately large and form leaf-like ..... *Microcentrum* Scudder

Caudal femora about the length of the tegmina; female ovipositor long, sword-like and gently recurved; size moderately large ..... *Amblycorypha* Stål

DICHOPETALA Brunner

In 1914, Rehn and Hebard monographed this genus then describing *oreoeca* as a new species from the Big Bend Region. Fourteen species were discussed; the genus finding its optimum development in western Texas and central Mexico where many species are found. Of the Texas species only *oreoeca* Rehn and Hebard and *brevihastata* Morse are indigenous to the Big Bend Region.

The males of this interesting genus resemble more closely decticids than phanerotropids, but the females have the ovipositor sharply recurved and the margins serrate with teeth. The genera body color is shining reddish brown or greenish with a dorso-lateral stripe of white edged with orange or red running the length of the body. The legs and antennae are very long and slender.

DICHOPETALA OREOECA Rehn and Hebard

Shafter Mt. 2 miles north of Shafter, 30, IX, 28, 3 ♂♂, 2 ♀♀ (elev. c. 5200 feet). Maguire Ranch, Upper Limpia Canyon, Davis Mts., 6, X, 1929, 1 ♀ (M. Hebard; Tinkham Cln.). Wilson's Ranch, west base of Mt. Emory, Chisos Mts., 17, VII, 30, 1 ♂, 1 ♀ nymph (elev. c. 5000 feet.). Cox's Ranch, south slope of Mt. Livermore, Davis Mts., 29, IX, 31, 2 ♀♀ (*Opuntia arborescens*).

The canyon behind Pulliam Bluff, Chisos Mts., at elevations from 4600 to 5000 feet is the type locality of the male and the female type is from Moss Well in the Chisos.

Rehn and Hebard state that *oreoeca* ranges from 3900 to 6500 feet in elevation. In the Chinatis it was found from about 4200 to 5500 feet. Aside from the Chinati, Chisos and Davis Mountains it is known from Montelovez, Coahuila, Mexico. *D. oreoeca* is a member of the Chihuahuan Upper Sonoran fauna.

DICHOPETALA BREVIHASTATA Morse

30 miles north of the Chisos Mts., 18, VII, 30, 4 ♂♂, 2 ♀♀ (Hebard Cln.).

Hebard has designated the College Campus, Mesilla Park, New Mexico as the male type locality and Riley's Ranch, Mesilla Valley, Dona Ana County, New Mexico, as the allotype or female type locality. This is the widest ranging species of the genus being known from Baboquivari and Santa Catalina Mountains of southeastern Arizona east through Trans-Pecos Texas to San Patricia County, Texas and south to Jaral, in southern Coahuila, Mexico.

Brevihastata does not occur in the mountains of Trans-Pecos Texas accord-

ing to Hebard. The specimens recorded here were taken on the creosote-covered mesa of the desert thirty miles north of the Chisos Mountains. These specimens were mating in bright sunlight near noon on a hot summer day. *Brevihastata* appears to be a member of the Chihuahuan Lower Sonoran fauna.

ARETHAEA SEMIALATA Rehn and Hebard

Presidio, 30, XI, 28, 2 ♂♂. Shafter Mountain, 2 miles north of Shafter, 30, IX, 28, 2 ♂♂, 2 ♀♀ (elev. c. 5200 feet).

This species is easily recognized by its uniformly pale grayish green coloration suffused with pinkish along the sides of the abdomen. The antennae and legs are very long and slender and the tegmina narrow and long in the male but much abbreviated in the female. The song of this species is a sort of fluttering waver closely similar to the sound produced by running into the wind with a wide thin band of golf ball rubber.

Rehn and Hebard described this species in 1914 from Garden Spring and Moss Well in the Chisos. It has been found throughout the Chisos and Chinati and Davis Mountains west to the Franklin Mountains near El Paso and Mesilla Valley near the Organ Mountains in New Mexico which represent the northwestern limits of distribution. The species is unrecorded from Mexico but undoubtedly exists in northeastern Mexico. *A. semialata* appears to be a member of the Chihuahuan Upper Sonoran fauna.

ARETHAEA ARACHNOPYGA Rehn and Hebard

Rehn and Hebard described this species in 1914 from the Ord Mountains in Brewster County, Trans-Pecos Texas. Marathon in Brewster County is the type locality of this species which is known from Marathon, the Ord Mountains and Monclova, Coahuila, Mexico. No specimens of this species were taken by the writer.

A. arachnopyga appears to be a member of the Chihuahuan Upper Sonoran fauna.

§ ARETHAEA GRACILIPES CERCIATA Hebard

Shafter Mountain, 2 miles north of Shafter, Texas, 30, IX, 28, 1 ♀ (allotype; Hebard Cln.; elev. about 5200 feet).

This subspecies was described by Hebard, in 1936, in his *Revision of the Genus Arethaea*. The allotype female was taken as indicated above by the writer and the male holotype was discovered by Rehn and Hebard in the canyon behind Pulliam Bluff, Chisos Mountains on September 7, 1912, at elevations between 4600 and 5000 feet.

Cerciata is the southeastern race of *gracilipes gracilipes* which occurs in the Panhandle of Texas, western Oklahoma, southern Colorado and New Mexico. It is the rarest of the species of *Arethaea* in Trans-Pecos Texas and larger than the nominal race *gracilipes*. Both sexes have long narrow tegmina surpassed by the wings by eight to ten millimeters.

Cerciata is known only from the Chinati and Chisos Mountains and appears to be a member of the Chihuahuan Upper Sonoran fauna.

INSARA ELEGANS ELEGANS (Scudder)

Candeleria, Presidio County, 27, IX, 28, 1 ♀. Ruidoso Hot Springs, Presidio County, 17, X, 28, 1 ♂ (*Larrea divaricata*). Presidio, 28, VIII, 39, 1 ♀ (at light); 15, IX, 29, 1 ♀ (cottonfields); 18, V, 30, 1 ♀ (at light).

Hormilia is a synonym of *Insara*.

This slender species is light green (sometimes pale brown) in color with a few short diagonal lines on the tegmina. The tegmina and wings are of the same length in both sexes and the wings are of tissue paper transparency.

Elegans, the nominal race, ranges from Trans-Pecos Texas west to western Arizona where in the extreme western desert portions it is replaced by *Insara elegans conseutipes* (Scudder). *I. elegans elegans* is a member of the Lower Sonoran fauna.

SCUDDERIA FURCATA FURCIFERA Scudder

Adobes, Presidio County, 27, IX, 28, 1 ♀. Chinati Mts., (7), 27, IX, 31, 2 ♂♂, 2 ♀♀ (fairly common at elevations from 4500 to 5000 feet). Cox's Ranch, south base of Mt. Livermore, Davis Range, 29, IX, 31, 1 ♂.

Spiloeris maculatus Rehn and Cockerell, is a synonym.

This species is commoner than the records would suggest as it is fairly common in the cotton fields of the Rio Grande Valley. It was fairly common at elevations of 4500 to 5000 feet on the northern slopes of the Chinatis in late September of 1931, where it was most frequently found in clumps of Sacahuiste or Bear Grass (*Nolina*).

From southwestern Texas *Scudderia f. furcifera* ranges to the Pacific and north to Caliente, Nevada and Colorado and south in Mexico to Tamaulipas, Vera Cruz and Oaxaca. This species appears to be a member of the Lower and Upper Sonoran fauna.

AMBLYCORYPHA Stål

In this handsome genus of katydids the female is easily recognized by the long and gently recurved ovipositor which distinguishes it from the short recurved ovipositor of *Scudderia* and *Microcentrum*. Two species occur in Trans-Pecos Texas, *insolita* and *huasteca*, the former recognized by its larger size and pink spots (male) and yellow spots (female) on the green tegmina.

AMBLYCORYPHA HUASTECA (Saussure)

Indio, Presidio Co., 29, IX, 28, 1 ♂ (*Prosopis pubescens*). 9 miles west of Marathon, Brewster Co., 3 ♂♂ (males common at night singing in low bushes of *Microrhamnus*).

Scudder's *Phylloptera caudata* is a synonym.

The records appear to indicate that this species is mainly Upper Sonoran for on the Marathon grasslands it was quite common at night singing in the scattered low clumps of *Microrhamnus* bushes. The song was a peculiar ticking sound like *t-t-t-t-t-tk* repeated over and over again at spaced intervals of time. The song is quite distinct from *A. insolita* which is similar but more fluttering in note.

According to Hebard (1931a) this species finds its northernmost limit of

distribution in Marshall County of northeastern Kansas. Eastern limits of its range are eastern Kansas and Oklahoma, Dallas and Galveston, Texas, thence ranging west to Clarendon, Kerrville and Uvalde, Texas. The Marathon and Indio records appear to be the first for Trans-Pecos Texas and Indio marks its southwestern limit of distribution in the United States. In Mexico it has been taken south to Tampico. *A. huasteca* is a member of the more humid section of the Lower Sonoran.

AMBLYCORYPHA INSOLITA Rehn and Hebard

Shafter Mt., 2 miles north of Shafter, Chinati Mts., 30, IX, 28, 5 ♂♂, 4 ♀♀ (singing on *Trixis californicus* in sun at about 5500 feet elev.). Chinati Mts., (3), 16, IX, 29, 1 ♂ (north base perpendicular cliff at 5400'). Cibolo Arroyo banks, 2 miles above Shafter, 16, IX, 29, 1 ♂ (Scout Lloyd Johnson; on *T. californicus*). Wilson's Ranch, west base Chisos Mts., 17, VII, 30, 1 ♀ (violet colored). 30 miles south of Marathon, Brewster Co., 18, VII, 30, 1 ♂ (Hebard Cln.). Six miles southwest Toyahvale, Davis Mts., Jeff Davis Co., 13, IX, 40, 3 ♂♂, 4 ♀♀ (night collecting on *T. californicus*). Nine miles north of Shafter, 13, X, 46, 2 ♂♂ (night collecting).

This handsome and rare species which was described in 1914, is the largest species of the genus. The principal host plant in the Chinati and Davis Mountains appears to be *Trixis californicus* although north of Shafter it was singing at night in a species of *Baccharis* growing along the edge of an arroyo. At the west base of Mt. Emory, near Wilson's Ranch, Chisos Mountains, the writer heard the males singing from plants growing on the perpendicular rock cliffs several hundreds of feet above the base. Whenever a cloud passed over the sun during the afternoon of July 17, 1930, these fluttering troubadours would burst forth in a chorus of song. On Shafter Mountain they were singing about 5 p.m. in the direct rays of the setting sun. The song of *A. insolita* is a sort of fluttering *shk-shk-shk-shk-shk* repeated at spaced intervals.

Insolita is known from the Chinati, Chisos and Davis Mountains of the Big Bend Region and from the Baboquivari, Santa Catalina and Pinal Mountains and Oak Creek Canyon in Arizona, although in that state it is very rare. *Amblycorypha insolita* is a member of the Mexican Upper Sonoran fauna whose distribution is similar to that already discussed under *Amblytropidea mysteca, Achurum sumichrasti, Rhammatocerus v. viatoria* and *Arenivaga grata.*

MICROCENTRUM RHOMBIFOLIUM (Saussure)

El Paso, Texas, 18, IX, 31, 1 ♂ (at light).

This large beautiful green species is easily recognized by the leaf-like appearance of the tegmina which are much widened in the central portions, and by the male subgenital plate being only moderately extended caudally as a flat plat. In *Scudderia* and *Amblycorypha* the subgenital plate is recurved.

This arboreal species is found throughout the Southwest wherever cottonwoods occur and it should be found dwelling in cottonwood groves along the Rio Grande near Presidio. It is also found on willows and other plants.

Microcentrum rhombifolium ranges across the southern United States north to Utah, Colorado and Kansas and south in Mexico to Sinaloa and Morelos.

PSEUDOPHYLLINAE

The Pseudophyllinae, the leaf-winged katydids, as their name indicates, have few representatives in the United States. In the tropical regions of the Old and New World there are many remarkable members of this subfamily, some of which are among the largest of orthopterans. The presence of a member of the Pseudophyllinae in the Chisos Mountains, the newly recognized genus *Paracyrtophyllus* Hebard, 1941, not only attests to the remarkable orthopteran fauna of the Big Bend Region, but further indicates considerable antiquity to that range at a time when the Southwest was humid rather than arid.

PARACYRTOPHYLLUS EXCELSUS (Rehn and Hebard)

Chisos Basin, Chisos Mts., 26, X, 46, 1 ♂ (night collecting; "quonking" in pine).

This handsome green katydid, belonging to the group Pterophyllae, was described by Rehn and Hebard, in 1914, from the Chisos Mountains. Moss Well at the foot of Pulliam Bluff at elevations of 4700 to 5000 feet is the type locality. There they found it common in the low scattered oaks (*Quercus Emoryi*) on the mountain sides.

A strong down-draft wind was blowing from the Chisos Basin to Window Rock, at nightfall of October 26, 1946, when I heard a faint sound which I thought was a wood-boring larva gnawing away close by. Taking my flashlight, I started down a steep narrow canyon in search following the sound, and to my surprise discovered that it became louder and louder. Presently when I heard the loud penetrating *quonk—quonk—quonk* my pulse quickened for I

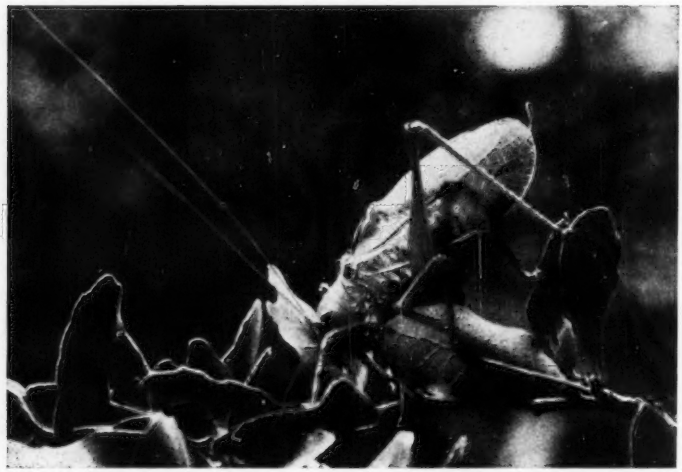


Fig. 35.—The Chisos Quonker, *Paracyrtophyllus excellus*, in a typical pose on a branch of the gray oak, *Quercus grisea*.

realized then it was the Chisos leaf katydid which I especially desired. Creeping forward quietly I finally spotted my first *Paracyrtophyllus* "quonking" away on a limb of a pine tree and fully one hundred yards from camp. I returned to camp and later with the aid of an electric spot-light lantern held by my wife, I managed somehow to maintain a precarious balance in the top of an oak long enough to capture my prize. The photograph will explain far better than words the features of this large katydid known only from the Chisos Mts. The greatly elongated subgenital plate is observed projecting beyond the apex of the tegmina. The nights in the Chisos Basin were getting cold at this time of year and this male was undoubtedly the last of that season's population. The writer spent several hours in night collecting on October 25 but not a single katydid was heard.

Whether *P. excelsus* occurs at high elevations on Chinati Peak remains to be discovered. The species, however, undoubtedly occurs in the lofty San Carlos Sierras, some fifty miles to the south in Chihuahua.

P. excelsus appears to be a member of the Chihuahuan Upper Sonoran fauna.

COPIPHORINAE

The cone-headed katydids of the subfamily Copiphorinae are large grass-inhabiting species commonest in areas where the grass grows tall and rank. They are recognized by their large size, usually green or gray coloration and by the cone-like fastigium that projects forward from between their eyes. In the United States quite a few species are represented in the southeastern states and Florida and many handsome species flourish in subtropical and tropical regions for this subfamily is tropicopolitan.

NEOCONOCEPHALUS ROBUSTUS CREPITANS Scudder

10 miles west of Marathon, Brewster Co., 21 Oct. 1946, 1 ♂ (singing by roadside in Johnson grass; male minus hind legs when captured).

This species is slightly larger and bears a longer fastigial cone than *Neoconocephalus triops* commonly found on the Sonoran Desert in Arizona and the Southwest. Despite the handicap of the loss of both hind legs this male was endeavoring to carry on the functions of the species and its song could be heard well over a distance of 100 yards.

This is the first record of this species for Trans-Pecos Texas as previously Cisco, Texas, marked its southwestern limit of distribution. Thus the Marathon record is an extension southwestward of approximately 375 miles in the range. *N. r. crepitans* is known from Sedan and White Bear Lake, Minnesota, to Cold Springs, New Jersey and south to Hastings, Florida; its western limits being Lincoln, Nebraska; Ellis, Finney and Morton counties, Kansas; Perkins and Mt. Sheridan, Oklahoma and Clarendon and Cisco, Texas. It is an inhabitant of the Upper Sonoran (humid) Zone.

As *Neoconocephalus triops* (Linn.) has an extensive distribution in the desert regions of the Southwest and is recorded by Hebard, 1932b, from Tampico, Tamaulipas and other Mexican states, it may eventually be found in the Big Bend Region.

CONOCEPHALINAE

The Conocephalinae are quite similar in general appearance to the cone-headed katydids but are much smaller in size. They have a world-wide distribution and are chiefly represented by the genera *Orchelimum* and *Conocephalus*. There are many species found in the eastern United States but few in the arid southwest.

ORCHELIMUM CONCINNUM CONCINNUM Scudder

Mouth of Lower Limpia Canyon, 20 miles SW. of Balmorrhea, 12 Oct. 1946, 1 ♂ (singing in bright sunlight on *Baccharis glutinosa* by edge of stream). 12 miles south of Marathon, Brewster Co., 22 Oct. 1946, 1 ♂ (in very tall goldenrod growing in wet ground near a roadside spring).

The genus *Orchelimum* averages slightly larger in size than *Conocephalus* and is recognized by the upcurved instead of straight ovipositor of the female and the cylindrical prosternal spines which in *Conocephalus* are very short or wanting.

The length of the ovipositors is the only criterion available in separating the nominal race, *O. c. concinnum*, from its northern race, *O. c. delicatulum* of the Dakotas and Minnesota. The nominal race ranges from Del Dio and Dallas, Texas, east to Homestead, Florida; north to New Hampshire, southern Ontario, Menominee, Michigan, and southeastern Minnesota and west to Lincoln, Nebraska, and Saline County, Kansas. The above records are the first for the Big Bend Region and as such mark a new southwestern distributional point some 200 miles west of Del Rio, the previous record.

CONOCEPHALUS STRICTUS (Scudder)

Davis Mts., 22, X, 28, 1 ♀. Ochoa, 12 miles upstream from Presidio, 8, X, 28, 1 ♀ (tall grass by edge of pond). Cox's Ranch, south slope of Mt. Livermore, Davis Range, 29, IX, 31, 1 ♀. 6 miles NE. of Ft. Davis, Lower Limpia Canyon, 12, X, 46, 1 ♂. 2 mi. E. of Paisano Pass, Brewster Co., 29, X, 46, 1 ♂.

C. strictus is distinguished from the other Nearctic species of the genus by having the female ovipositor longer than in any other species and ranging from 19.0 to 30.0 mms. in length. The wings are abbreviate in this species.

In Trans-Pecos Texas, *C. strictus* is a rare species. In 1915, Rehn and Hebard recorded it from Marathon and Del Rio. It has a very extensive range in the United States, from southeastern Arizona to North Carolina and north to Staten Island, Pennsylvania, Illinois, southwestern Minnesota to Hot Springs, South Dakota. Its western limits are Kearney, Nebraska; Syracuse, Kansas and Cisco, Texas. It has not been reported as yet from Mexico.

C. strictus appears to be a member of the Upper Sonoran fauna. As *Conocephalus fasciatus fasciatus* has a very wide range in the United States it may possibly occur in the tall grasslands of the Transition Zone at higher elevations in the Davis Mountains.

DECTICINAE

The members of this interesting subfamily are known as shield-backed katydids because the pronotum in most genera is much enlarged and caudally

produced to protect the small tegminal pads. Several genera such as *Capnobotes* and *Anoplodusa* are fully winged and *Rehnia* and *Zycloptera* have tegmina and wings not quite extending to the apex of the abdomen. Genera with small tegminal pads include: *Eremopedes, Ateloplus, Pediodectes, Idiostatus, Idonotus, Decticita* and others. Only *Anabrus* and *Peranabrus* of the northwestern states are injurious to crops. The subfamily reaches its greatest development in the Sierra Nevada region of California where *Aglaothorax* and *Neduba* and *Acrodectes* are also found. The desert regions of Trans-Pecos has seven species, two of these were discovered by the writer and described by Mr. Morgan Hebard of Philadelphia.

KEY TO THE GENERA OF THE DECTICINAE OF TRANS-PECOS TEXAS

1. Tegmina and wings not reaching the apex of the abdomen 2

   Tegmina and wings very long, exceeding the tip of the abdomen; color grayish, wings black; size large; ovipositor very long and gently decurved ..... *Capnobotes* Scudder

2. Tegmina longer than the pronotum which is green, subsellata and margined posteriorly with pearly white; body entirely foliage green; wings fan-like mottled with patches of green and black, ovipositor very long and gently decurved; all legs armed with spines ..... *Rehnia* Caudell

   Tegmina projecting for a distance shorter than the pronotum; all legs not heavily armed with spines; pronotum flat and not subsellate; ovipositor not very long and gently recurved 3

3. Posterior margin of the pronotum convexly rounded; prosternum armed with spines; size medium to large ..... *Pediodectes* Rehn and Hebard

   Posterior margin of the pronotum squarely truncate; prosternum not usually armed; size small to medium ..... *Eremopedes* Cockerell

CAPNOBOTES FULIGINOSUS (Thomas)

Paisano, Presidio Co., 23, VII, 29, 1 ♂ (in small cave). Kelligan Canyon near El Paso, 18, IX, 31, 6 ♂♂ (taken by night collecting). North end of Davis Range, 6 miles southwest of Toyahvale, 13, IX, 40, 1 ♂ (night collecting). 2 miles north of Pine Springs, Texas, 10, X, 46, 1 ♀ (pinyon zone).

Fuliginosus is the largest and one of the handsomest members of this subfamily. It is easily recognized by its large gray size, long tegmina and wings which are coal black. Its spiny forelegs are used to capture prey. When annoyed it raises its tegmina and wings over its back in quite a striking show apparently to warn its enemies. The song is a loud and continuous and a sort of quavering sound difficult to interpret but something like *zik-k-k-k-k-k—z:k-k-k-k-k-k—zik-k-k-k-k-k* with the *ks* fluttering and undulating in tone.

The species matures in mid-June and lives until November. It is believed the eggs are laid in the fall and hatch in the early spring. About 50 eggs are laid. In Texas the host plant was *Acacia Greggii* but in Arizona Palo Verde *Cercidium aculeatum* is favored and also mesquite *Prosopis velutina.* Other host plants include *Atriplex confertifolia* and *Larrea divaricata,* the creosote plant.

Fuliginosus is commonest and of the largest size in Arizona where it is found throughout the desert mountain ranges of the southwestern half of the state. It ranges north to the Beaverdam Mt. Pass of extreme southwestern Utah

and Walker's Lake, Nevada, Lake Tahoe to Los Angeles, California. East it is found rarely to the Davis Mountains which appear to be the first records for the Big Bend Region. East of Arizona the writer has taken it as far north as Water Canyon, Magdalena Mts., New Mexico, and just north of Pine Springs on almost the New Mexico border. In 1944, Tinkham presented a complete account of this handsome species, and the enquiring student is referred to that work. *C. fuliginosus* appears to be an inhabitant of the Lower Sonoran Faunal Zone but it is also found at the lower edge of the Upper Sonoran Zone.

REHNIA CERBERUS Rehn and Hebard

Chinati Mts., (1), 27, IX, 31, 8 ♂♂, 1 ♀ (night collecting); 30, IX, 28, 1 ♀, one mile south of Shafter, Chinati Mts., 13, X, 46, 2 ♂♂ (*Acacia Greggii;* night collecting). Ruidoso Hot Springs, 42 miles up river from Presidio, Presidio Co., 14, X, 28, 1 ♂ (singing in evening before sundown; attacked the collector). Haciendita, 9 miles up river from Presidio, 14, IX, 28, 1 ♂. Presidio, 10, IX, 28, 1 ♀ nymph (in mesquite tree). Marfa, 1 ♀ (G. Gotthold). 20 miles north of Chisos Mts., Brewster Co., 18, VII, 30, 1 ♀ nymph. 1 mile north of Bunton's Flat, 29 miles north Presidio, 20, X, 46, 3 ♂♂ (singing in *Acacia* trees before sundown). 3 miles east of Alpine, 21, X, 46, 5 ♂♂, 1 ♀ (common in low *Acacia Greggii* bushes covering a small rocky knoll). Persimmon Gap, 44 miles south of Marathon, Brewster Co., 22, X, 46, 1 small ♂ (in Mexican Persimmon *Diospyros texana*). 10 miles north Government Springs (Wadi Burnham Ranchhouse), 24, X, 46, 1 ♂ seen in dense clump of *A. Greggii* at night but could not be captured. Chisos Basin, Chisos Mts., 26, X, 46, 2 ♂♂ (*A. Greggii;* elev., c. 6200 feet).

Cerberus is one of the handsomest members of this striking genus. Its coloration is deep foliage green with nacreous trimmings on the posterior margin of the pronotum and on the thoracic pleurites. When annoyed this species portrays interesting aggressive habits by producing a few sharp squeaks, spreading its beautifully mottled fan-like wings as it rears back with the spiny forelegs held outstretched above its head and its powerful mandibles wide open for action. In this combatant pose it is ready to fight all comers. In fact it will jump forward to the attack a distance of half a foot as I discovered from my very first experience with this splendid creature at the Ruidoso Hot Springs. True to its name of Cerberus, in Greek mythology Hercules' dog guarding the gates of Hades, this handsome species is most unusual for an orthopteran and it guards well its own integrity. For a full account on this strange decticid the reader is referred to the author's works of 1944.

The adults are found from July to November and the eggs (one female possessed 54) are laid in the fall and hatch in the spring so that by midsummer the nymphs are mature. Mesquite and catclaw are the favored host plants, rarely *Karwinskia Humboltiana* (in Mexico) is also eaten. The species is strongly carnivorous in captivity but in nature is undoubtedly herbivorous due to its foliage green coloration.

The song of *cerberus* is a strong *tszeee-e-e-k—tszeee-e-e-k—tszeee-e-e-k* rapidly repeated and continued indefinitely until disturbed.

Cerberus is definitely restricted to the Chihuahuan Desert of Trans-Pecos Texas and northeastern Mexico where the writer has taken it in Nuevo Leon (28 miles NW. of Monterey) and in Coahuila (42 miles NW. of Saltillo and

6 miles north of Parras). Hebard, in 1932, reported it from Jaral, Coahuila. *Cerberus* is a member of the Chihuahuan Lower Sonoran fauna.

REHNIA VICTORIAE Caudell

15 miles east of Sanderson, Texas, 14, VIII, 40, 1 ♂. Sand dunes near Monohans and Odessa, Texas, 2, X, 31, 4 ♂♂ (night collecting). Eagle Pass, Texas, 14, VIII, 40, 2 ♂♂ (night collecting). Laredo, Texas, 15, VIII, 40, 1 ♂; 10, IX, 40; 1 ♂ (night collecting).

This species differs from *cerberus* by its smaller size and less spiny legs, the short femoral spines of the legs green and not black as in *cerberus*.

The life history is probably similar to that in *cerberus* although these have not been studied. The host plants, however, differ as *R. victoriae* is indigenous to the Tamaulipan Semi-Desert Bushland fringing the Chihuahuan Desert on the east and this Bushland is characterized by such plants as *Acacia Berlandieri, Prosopis glandulosa, Karwinskia* and *Pithecolobium*. It has been taken on *Karwinskia Humboltiana, Prosopis glandulosa, Acacia Berlandieri* and blackbrush (*Flourensia cernua*). The penetration of various plants west of the Pecos River accounts for *victoriae* being found in this region. The song is a rapid, long continued *zeee-e-e-e-t—zeee-e-e-e-t—zeee-e-e-e-t*.

The species was named for Cuidad (city) Victoria, capital of Tamaulipas, Mexico. It is a member of the Lower Sonoran fauna pertaining to the Tamaulipan Semi-Desert Bushland. In the United States it ranges north to the extreme southwestern corner of Kansas (Hebard 1931).

KEY TO THE SPECIES OF PEDIODECTES OF TRANS-PECOS TEXAS

Lower part of the black face with a triangular patch of white ..... *bruneri*
Lower part of black face crossed by a broad, decurved band of white ..... *tinkhami*

§ PEDIODECTES TINKHAMI Hebard

The type male was collected by the writer at locality (1) about 2½ miles south of Shafter in the Chinati Mountains foothills on Sept. 29, 1928. The female type came from the Wadi Burnham Ranch at the north base of the Chisos Mountains in Brewster County, Texas. Paratypes were also taken at the latter locality and from the Ord Mountains by the late field naturalist Mr. O. C. Poling. A female nymph representing the first Mexican record was taken at the San Carlos Mines, 10 miles southwest of San Carlos, Chihuahua, Mexico, on July 3, 1930.

This interesting and rare species is quickly separated from all other desert decticids by the broad arcuate band of creamy white crossing the middle of the black face. The coloration is cinnamon buff mottled with clay color and microscopic streaks of tawny olive. The caudal femora are tinged with delicate green.

Little is known of the biology of *P. tinkhami* although the large nymphs present in July mature in August. The eggs are probably laid in the fall and hatch the next spring. Many adults meet accidental death by falling into pools of water in the arroyo bottoms while seeking water. I have found such speci-

mens in the Chinati and Chisos Mountains but unfit for preservation. The song of this species is not known nor is the host plant known.

Pediodectes tinkhami is a member of the Chihuahuan Lower Sonoran fauna

Fig. 36.—Type locality of *Pediodectes tinkhami* Hebard. The dominant plants at about 4200 ft. elevation are lechuguilla (*Agave lecheguilla*), sotol (*Dasylirion texanum*) and many other less important plants.

and is at present known only from the Chinati and Chisos Mountains of Trans-Pecos Texas and the San Carlos Sierras of northern Chihuahua, Mexico.

PEDIODECTES BRUNERI (Caudell)

Davis Mts., Prudes Ranch, elev. about 6000 feet, 6, X, 29, 1 ♂; Cox's Ranch, south slope of Mt. Livermore, Davis Mts., elev. about 7800 feet, 29, IX, 31, 5 ♂♂, 6 ♀♀ (in mountain grass). Twenty miles west of Ozona, Texas, 13, IX, 40, 2 ♀♀. Chisos Basin, Chisos Mts., Brewster Co., Tex., 26, X, 46, 1 ♀ (scrub oak and grass at 6500' elev.)

The type locality of this species is Belfrage, Texas. It is smaller than *tinkhami* and darker colored and the two species can be easily separated according to the key. Little is known concerning the biology of *bruneri* but the eggs are probably laid in the fall and the nymphs emerge in the spring, to become adults in August or early September. The adults probably feed on grasses.

P. bruneri is known from the Davis Mountains east to the Edwards Plateau, south to Belfrage and north to Quanah, Texas. It is an inhabitant of the Upper Sonoran Faunal Zone. Its faunal affinities are not definitely known.

KEY TO THE SPECIES OF EREMOPEDES OF TRANS-PECOS TEXAS

Tegmina jet black with the veins outlined in yellow; supra-anal plate deeply grooved; subgenital plate cleft ..... *covilleae*

Tegmina not jet black but more brownish with veining not as conspicuous; supra-anal plate deeply cleft, subgenital plate entire ..... *scudderi*

EREMOPEDES SCUDDERI Cockerell

Dawson's Ranch, (8), 8, VII, 29, 1 ♀ (feeding on pollen of flower stalk of *Dasylirion texanum*). Chinati Mts., (3), 16, IX, 29, 1 ♂ (in clump of *Agave lechuguilla*). Paisano, 22, VI, 30, 1 ♂ juv. (in grass). Wadi Burnham's Ranch, north base of Chisos, 18, VII, 30, 1 ♀ (from fly trap baited with dough). Creosote mesa 20 miles north of Chisos, 18, VII, 30, 1 ♂ (swept from creosote). Kelligan Canyon near El Paso, Texas, Franklin Mts., 18, IX, 31, 3 ♂♂, 1 ♀ (night collecting; gray phase). Bunton Flat, 29 miles north of Presidio, 20, IX, 31, 1 ♂ (trilling at night on *Opuntia arborescens*). North end of Davis Mountains, 6 miles SW. of Toyahvale, 13, IX, 40, 2 ♂♂. Six miles east of Marfa, 13, VIII, 40, 2 ♀♀ (hiding in *Clematis Drummondi*). 10 mi. west of Marfa, 30, X, 46, 1 ♂.

Ateloplus macroscelus Rehn and Hebard, described from El Paso in 1909 is a synonym.

This interesting species is usually found in the green or gray color phase with the dorso-lateral lines marked with a lacery of pink and white, with yellowish margins to the pronotum. Optimum specimens from the desert regions are of large size but in northern New Mexico and northeastern Arizona, on the periphery of its range, its size is small.

The female lays about twenty-four eggs in the fall which undoubtedly hatch in the spring and become adults in July. The song is a soft low *zeeee-e—zeeee-e --zeeee-e—zeeee-e* continuous for long periods of time. The species is thamnophilous and phyllophagous on the creosote bush principally although in various parts of its range *Acacia constricta, Sarcobatus vermiculatus, Dasylirion texanum,* are the host plants. When confined specimens eat one another as is typical of this group.

E. scudderi is a member of the Chihuahuan Lower Sonoran fauna and is confined to the Chihuahuan Desert. It is found in Trans-Pecos Texas and its distribution extends up the Rio Grande Valley into northern New Mexico and southeastern Colorado and across the desert areas of the northwestern portions of New Mexico to Concho, Arizona. These specimens, however, on the periphery of its range are of dwarf size. In southern Coahuila, Mexico, in 1940, the writer found it common on the creosote bushes of the Chihuahuan Desert, where the specimens were of optimum size.

§ EREMOPEDES COVILLEAE Hebard

Hebard described this species in 1934, from several specimens taken by the writer (July 18, 1930) on creosote, twenty miles north of the Chisos Mountains. This locality, desert mesa, is the type locality and is southeast of Persimmon Gap.

My notes made at the time showed that it differed from *E. scudderi* with which it was associated on the creosote plant, by the following characteristics: posterior portions of the pronotum margined with a broad band of buff; tegmina somewhat greater in length and jet black with the network of veins in yellow; supra-anal plate deeply grooved whereas in *scudderi* it was deeply split and by the subgenital plate being split for most of its length whereas in *scudderi* it was entire.

Nothing is known about the biology of this rare species which is known only from two male adults and one or more nymphs. Efforts were made to find

it at the type locality, in October, 1946, but without results. *E. covilleae* is a member of the Lower Sonoran Chihuahuan fauna and it should be found in the desert areas of Coahuila in northeastern Mexico.

Dr. T. H. Hubbell has specimens of what may prove to be a new genus of decticids from the Big Bend Region so that the prospects of discovering new elements in this region is still not completely exhausted. However, the writer believes that the likelihood of finding new species will be much less than even some years ago. A number of new records for the Big Bend may still be found on the eastern border of Brewster County.

The GRYLLACRIDIDAE

The members of this family, first recognized as a family by Dr. H. H. Karny of Vienna, in 1926, are either winged or wingless. The very large genus *Gryllacris* which is tropical and subtropical in distribution has very long antennae and is winged. The long antennae are used in the capture of smaller insects living on the tropical verdure of leaves and upon which they exist. Many other genera of the nine subfamilies are wingless. The camel or cave crickets of the subfamily Rhaphidophorinae have been frequently classed as a subfamily of the Tettigoniidae, but rightly belong to the Gryllacrididae. The Rhaphidophorinae are very ancient in origin, having probably developed in middle Mesozoic times, and there is every indication that modern members have shown little change since the Eocene according to the authority Dr. Theodore H. Hubbell who monographed the Nearctic representatives of the genus *Ceuthophilus* in 1936, and described many new species at that time. Only the genus *Ceuthophilus* has been found in Trans-Pecos Texas. As the various members of this genus are difficult to dissociate no keys will be presented to this genus. Specimens should be sent to Dr. Hubbell at the University of Michigan for determination.

RHAPHIDOPHORINAE

CEUTHOPHILUS VARIEGATUS Scudder

Presidio, 28, VIII, 29, 1 ♂; 2, VII, 30 and 26, IX, 31, 3 ♂♂, 1 juv. ♂, 1 juv. ♀ (nymphs taken in showerhouse); 19, X, 46, 1 ♂. An arroyo valley 8 miles north of Presidio, 21, IX, 31, 1 ♂ (feeding on dead scorpion at night). Chinati Rancho, 22 miles up river from Presidio, 34, IX, 31, 1 ♂, 2 ♀♀ (in large adobe house with concrete floors).

This large and robust cave cricket is often seen at night jumping across the desert floor but it is seldom captured due to its great jumping powers which sends it off into the night quicker than the light can follow its actions.

C. variegatus is a member of the *Pallidus* group containing two other members namely *pallidus* Thomas 1872, and *isletae* Hubbell 1936, all of which are found in the Big Bend Region of Trans-Pecos Texas. It is a member of the Chihuahuan Lower Sonoran fauna and its range extends up the Rio Grande Valley from the Big Bend Region to Mesilla Park, New Mexico, and east to Uvalde County and the mouth of the Rio Grande. South in Mexico it has been recorded from Matamoros, Tamaulipas, San Lorenzo, Coahuila which is typically Chihuahuan Desert and from San Pedro (Ocampo) in Zacatecas.

CEUTHOPHILUS PALLIDUS Thomas

Hubbell reports this wide-spread species from the Ord Mountains of Brewster County. Its range is very extensive extending throughout the Great Plains region from southern Manitoba and Saskatchewan south to the Ord Mountains and east of the Rockies to central Iowa, eastern Kansas and Oklahoma and central Texas. In the Southwest its optimum zone is from 5000 to 9000 feet elevation in the mountains of New Mexico and the non-desert ranges of Arizona, where it has been found as far west as Flagstaff. *C. pallidus* appears to be a member of the Northern Short Grasslands fauna of the Transition Zone.

CEUTHOPHILUS ISLETAE Hubbell

This comparatively new species was described from seven specimens with the holotype coming from Albuquerque and the female allotype from Maxwell, Colfax County, New Mexico. One male, two females and one juvenile female were taken in 1928, by that veteran collector, the late Mr. O. C. Poling, in the foothills west of the Ord Mountains of Brewster County.

Hubbell believes this species to be an inhabitant of the grasslands on the slopes of the mountain ranges extending from the Big Bend Region into northern New Mexico. It thus would appear that *C. isletae* is probably a member of the Southwestern Mountain Transition fauna.

CEUTHOPHILUS REHNI Hubbell

Hubbell described this new species from four specimens, the types collected by Mr. O. C. Poling in the foothills west of the Ord Mountains and a female from Limpia Canyon in the Davis Mountains of Jeff Davis County, at an elevation of 500 to 5500 feet.

Hubbell believes that this species inhabits caves and talus cavities on rocky slopes and canyon sides and thinks that its distribution will eventually be found to extend in similar habitats into New Mexico. From the little known facts concerning this species, it would appear that it is best placed as a member of the Southwestern Mountain Transition fauna. In Hubbell's monograph it is a member of the *longipes* Group; *C. longipes* being known only from the depths of the Carlsbad Caverns.

CEUTHOPHILUS POLINGI Hubbell

Mouth of Upper Limpia Canyon near Ft. Davis, 13, X, 46, 1 juv. ♂ (night collecting; det. Hubbell 1948).

C. polingi is named in honor of that great field collector Mr. O. C. Poling, formerly of Ft. Davis, Texas, who died in the spring of 1929. Many of the new species of *Ceuthophilus* described from the Big Bend Region, by Hubbell, were colletced by Mr. Poling. *C. polingi* is a member of the *Silvestris* group of the genus *Ceuthophilus* which contains six species one other of which, namely *carlsbadensis*, has been found in the Big Bend.

Poling's cave cricket was described from only two males, holotype and paratype, collected at Ft. Davis, October 15-28, 1927. The Ft. Davis region abounds in oaks and rocky mountain slopes and from the meagre information

available it would appear that *polingi* is a member of the Chihuahuan Upper Sonoran fauna.

CEUTHOPHILUS CARLSBADENSIS Caudell

The types of this interesting species were described by Caudell, in 1924, from the Carlsbad Caverns. It is distinguished from *C. longipes,* known only from these caverns, by its larger size and longer legs. They are so pale in color that their stomach contents can be seen through the translucent walls of the abdomen, according to Bailey in his *Animal Life of the Carlsbad Caverns* (1928). When approached or alarmed, they made long hops, but were generaly slow and sluggish for crickets, moving slowly and touching the ground in front with the long antennae as if feeling their way. "They apparently fed on insect remains dropped by the myriads of bats in the guano-bat caves, and they in turn were preyed upon by the cave mouse *Peromyscus leucopus tornillo.*"

C. carlsbadensis has also been found in the caves of Dark Canyon, 12.5 miles southwest of the Carlsbad Caverns and the only Big Bend record is from the cave at Phantom Lake, near Ft. Davis in the Davis Mountains. Being strictly cavernicolous it is difficult to assign this species, but it is believed to be a member of the Chihuahuan Upper Sonoran fauna.

§ CEUTHOPHILUS UTAHENSIS Thomas

Cox's Ranch, south base of Mt. Livermore, Davis Mts., 39, IX, 31, 1 ♂, 1 ♀ (taken in a mole burrow under a rotting log in a clump of pine trees at about 8300 feet elevation by E. R. Tinkham).

This is the first record for Texas of this western species known from Utah and Arizona. This species is of rather small size, of a uniform buffy brown coloration and with the caudal femora often strongly bowed outwards in the male. Like many species of *Ceuthophilus* this species prefers to dwell in rodent burrows under logs in the pine forests of high mountain slopes.

There are two phases, the northern *utahensis* and the southern *uniformis.* The *uniformis* phase in its range is typical of that for members of the Southwestern Mountain Transition fauna. Its range thus extends from the Davis Mountains, where it is isolated in Texas, north to Estes Park and Ft. Collins, Colorado and throughout many of the mountain ranges of New Mexico.

CEUTHOPHILUS CONICAUDUS Hubbell

Chinati Mts., 1 mile south of Shafter, 19, X, 46, 1 ♂ (night collecting in a small arroyo; det. Hubbell 1948).

C. conicaudus is a member of the *Secretus* Group of the large diversified *Lapidicola* series which contains 22 species placed in 8 different groups. Already mentioned above is the *Pallidus* group with three species namely *variegatus, pallidus* and *isletae* and *rehni* of the *Longipes* group. The *Secretus* group contains *secretus, conicaudus* and *aztecus. Conicaudus* is very closely allied to *secretus* replacing that species in the more arid areas of Texas and Oklahoma. The types, male and female, were described from "Camp Boulder" in the Wichita Nat'l Forest, Comanche County, Oklahoma. Its range closely follows the distribution of mesquite in Texas and Oklahoma, according to

Hubbell, and has been recorded from Woods, Comanche and Harmon counties of Oklahoma south to Austin and San Antonio, Texas, thence west to Montell in Uvalde County, the Big Bend Region and the caves in Dark Canyon close to Carlsbad Caverns, New Mexico. In the Big Bend, Hubbell reports it from the cave near Phantom Lake and Ft. Davis in the Davis Mountains of Jeff Davis County and from the foothills west of the Ord Mts., Tibbett's Ranch near Alpine and from Boot and Upper Juniper Springs in the Chisos Mts. of Brewster County.

C. conicaudus is with great difficulty placed because its range appears to be rather unusual and the writer feels it is best to leave it unassigned for the present.

The GRYLLULIDAE

The crickets, represented by several genera and species in a number of subfamilies, are poorly represented in the Big Bend Region. All, with the exception of the large black field cricket, *Gryllulus assimilis*, are rather uncommon in Trans-Pecos Texas. The field cricket is ubiquitous over the entire United States and in some sections becomes an important economic species. Members of the Oecanthinae, the tree crickets, also assume economic importance in the northwestern states.

KEY TO THE SUBFAMILIES OF THE GRYLLULIDAE OF TRANS-PECOS TEXAS:

1. Hind legs armed with rows of long spines on the tibiae 2
   Hind legs without rows of long spines on the tibiae; body covered with scales; pronotum flat and very large ..... MOGOPLISTINAE
2. Head vertical, form robust, color brown or black 3
   Head horizontal, form slender and pronotum narrow, color whitish green; caudal tibiae armed with long spines interspersed with minute teeth; tree crickets ..... OECANTHINAE
3. Minute, flat, wingless crickets living as guests in nest of ants; caudal femora greatly enlarged, eyes very small; myrmecophilous or ant-loving crickets ..... MYRMECOPHILINAE
   Small to large crickets living in grass or vegetation; caudal tibiae without small teeth between the spines 4
4. Size very small with bristles covering the body and legs; tibiae armed with long movable spines; lawn crickets ..... NEMOBIINAE
   Size medium to large without bristles on body or legs; caudal tibiae with all spines immovable; field crickets ..... GRYLLULINAE

GRYLLULINAE

GRYLLULUS ASSIMILIS (Fabricius)

Presidio, common also in the Chinati Mountains.

Uvarov of the British Museum has proposed the name *Gryllulus* since *Gryllus* does not refer to this cricket. This species and its many forms ranges over the whole of the United States and Mexico. In the arid Southwest the variant *personatus* with long flying wings is the common form. The field cricket is an inhabitant of both the Lower and Upper Sonoran Zones.

MIOGRYLLUS LINEATUS (Scudder)

This species from Brownsville, Texas, west to San Diego, California, undoubtedly occurs in the Big Bend Region but as yet has not been reported.

NEMOBIINAE

NEMOBIUS CAROLINUS NEOMEXICANUS Scudder

Ft. Davis, mouth of Upper Limpia Canyon, 13, X, 46, 1 ♂ (singing in crevices in bark or root of giant cottonwood at night).

This specimen was identified by Dr. A. B. Gurney of the United States National Museum. An unidentified specimen taken at Presidio lights, in late August, 1929, probably represents this same species. This species ranges west to southern California north to Littlefield, Arizona, and south into Mexico. It is an inhabitant of the Lower Sonoran Zone.

NEMOBIUS CUBENSIS MORMONIUS Scudder

This species found in bermuda grass areas in damp places from Texas to Arizona and north to Nevada, Utah and Colorado should be found eventually in the Big Bend Region, perhaps in the Rio Grande Valley.

OECANTHINAE

OECANTHUS CALIFORNICUS Saussure

Presidio, 28, IX, 29, 1 ♂.

This is the commonest species of tree cricket found in the Rio Grande Valley and at night its purled lute-like trilling comes softly and distinctly from the dense thickets bordering the cottonfields. The range of this species is from Oregon and Idaho south to Costa Rica and as far east as western Texas.

OECATHUS sp.

Ruidoso Hot Springs, 10 miles north of Ruidoso, Presidio Co., 18, IX, 28, 1 ♂ (trilling at night in *Yucca Torreyi*).

A series of this species is needed before its identity can be satisfactorily established. It may possibly represent a new species.

MOGOPLISTINAE

CYCLOPTILUM COMPREHENDENS FORTIOR Hebard

12 miles north of Presidio on the desert mesa, 30, IX, 28, 4 ♂♂, 1 ♀ (swept from *Larrea divaricata*). Chinati Mts., 4, VIII, 29, 1 ♀ (on *Larrea*).

In 1931, Hebard described *fortior* as a new subspecies and designated Ajo, Pima County, Arizona, as the type locality stating that the series from the Big Bend Region and southern Arizona average slightly larger than those elsewhere in its range.

This small, interesting cricket inhabits the desert regions from Trans-Pecos Texas to southeastern California and south into Coahuila and Sonora, Mexico. It is thamnophilous dwelling on creosote and other dominants such as *Flouren-*

sia and *Chrysothamnus* or rabbit brush. *Fortior* is a member of the Mexican Lower Sonoran fauna.

CYCLOPTILUM COMPREHENDENS COMPREHENDENS Scudder

No specimens of this, the nominal race, were taken by the writer although Hebard, 1931d, records a series from the Davis Mountains and others from east of the Pecos River.

HAPLOSPHYRUM BOREALE (Scudder)

Ruidoso Hot Springs, 16, X, 28, 1 ♂ (in detritus under drooping legume in an arroyo canyon). Chinati Mts., (1), 16-18, X, 46, 3 ♀♀ (found hiding under limestone rocks on mountain side in daytime). Chisos Basin, elev. 6000 feet, 24, X, 46, 1 ♂ (under rock).

The range of this purplish gray cricket extends from Brownsville, Texas, west through New Mexico and Arizona, where it is rare, to California. In Mexico it has been found in Lower California and on some of the islands adjacent to its coast. The writer took a female specimen on Feb. 27, 1947, under a rock on a mountain side 5 miles north of Mesquital, Baja California, N. lat. 28.5°.

Hebard states that *H. boreale* may eventually prove to be only a race or synonym of the Mexican *Haplosphyrum aztecum* (Saussure).

H. boreale is a member of the Lower Sonoran fauna.

MYRMECOPHILINAE

No members of the tiny brown ant-loving crickets were taken by the writer although they undoubtedly occur in the ant nests in the Big Bend Region.

Summary with Especial Reference to Faunal Zones and Faunae of Midwestern North America

The preceding pages have discussed the floral and faunal characteristics of the region concerned and have dealt in detail with the respective members of the orthopteran fauna found in the Big Bend Region of Trans-Pecos Texas.

The florae of the Lower and Upper Sonoran and Transition Zones have been briefly but carefully described and divided into their component parts. The Lower Sonoran Zone includes the Rio Grande Valley of mesquite, the desert mesa of creosote, ocotillo and other plants, and the flora found at elevations of from 4200 to 4800 feet in the Chinati Mountains. The Upper Sonoran Zone, as discussed, comprises various types of grasslands and their associated orthopteran faunae. The Transition Zone was seen to be composed of the oak and pine clothed mountain slopes of the Davis Range and certain high, north-facing slopes in the Chinati and the Chisos Mountains.

Approximately 2000 specimens comprise the basis of this study, and these with few exceptions were collected by the writer. One hundred fifty species representing eighty-nine genera are recorded from the Big Bend Region of Trans-Pecos Texas and an additional nine are listed as probably occurring in the area. Of those recorded one hundred thirty-six are reported from Presidio

County alone—proof of the remarkable orthopteran fauna developed in that particular county. Of the 150 species, 97 belong to the grasshoppers or Acrididae; 22 pertain to the katydids or Tettigoniidae; 8 to the camel crickets of the family Gryllacrididae; 9 to the true crickets; and the remaining 23 are divided as follows: 9 cockroaches, 5 mantids, 7 stick insects and 2 grouse locusts of the family Tetrigidae.

Of the various subfamilies of the Acrididae, the band-winged members of the Oedipodinae, represented by 33 species, indicate that this group of soil-loving grasshoppers are especially adapted to the semi-desert regions of the Southwest. The slant-faced grasshoppers of the subfamily Acridinae with 27 known species and the Cyrtacanthacrinae, the spine-breasted grasshoppers, with 30 species, reveal that these two subfamilies are also very well represented. The toad-hoppers are of especial interest since they are the only two Nearctic representatives of a large and widespread Gerontogeic subfamily, the Pamphaginae. The leaf-katydids of the Phanerotropinae are well represented with 10 species. With the discovery of two new species of shield-backed katydids, the Decticinae now with 7 species assume new interest and importance. One pseudophyllid from the Chisos has been recorded.

Two decticids, *Pediodectes tinkhami* and *Eremopedes covilleae*, and a subspecies of the leaf-katydid, *Arethaea gracilipes cerciata*, were discovered by the writer during 1928-1930 and were described by Mr. Morgan Hebard in 1934 and 1936a. A new species of bird-winged locust, *Schistocerca chinatiensis* Tinkham, was found by the writer in October, 1946 and is described in this work. In addition Dr. Theodore H. Hubbell in his monographic work in 1936, described three new camel crickets from this region; namely, *Ceuthophilus rehni, C. isletae* and *C. polingi* and recorded several additional species for the first time from this area.

Two new North American records, north of Mexico; namely *Zapata brevipennis* and *Netrosoma nigropleura* have been reported. Three species: *Amblytropidea mysteca, Rhammatocerus v. viatoria* and *Clematodes larreae* are recorded from areas east of Arizona for the first time and are also first Texas records. New Texas records include the following species: *Heliaula rufa, Trimerotropis cyaneipennis,* and *T. strenua, Heliastus benjamini, Melanoplus desultorius* and *Ceuthophilus utahensis.*

The following species, although not as yet known from the Big Bend Region, will probably be found there: *Syrbula admirabilis, Amphitornus ornatus, Melanoplus femur-rubrum femur-rubrum, M. m. mexicanus, M. herbaceus, Neoconocephalus triops, Conocephalus f. fasciatus, Miogryllus lineatus* and *Nemobius cubensis mormonius.*

A panoramic view of the Big Bend Region would exhibit by its physiographical, phytogeographical and zoogeographical features the following faunal zones of the Austral Faunal Region: the Lower Sonoran Zone occupied by the desert, the Upper Sonoran Zone comprising the semi-arid grasslands, and the Transition Zone restricted to the mountain peaks of the Davis, Chinati and Chisos ranges. This view, however, would not reveal the various faunal subdivisions or faunae of these zones. This is due to the fact that the components

of the various zones exist side by side, some finding in that particular zone the sum total of the conditions favorable for their optimum development, while others are suppressed by conditions less favorable to their growth. There is an overlapping and intermingling of species from the various zones, especially the ecotonic areas where the zones intergrade. We find that some species are non-discriminators of zones due to their tolerance to a wide range of climatic conditions, while others may be rare because they require a particularly favorable set of conditions before they can thrive. This is expressed in a number of species which have evolved and remain within a given region where they live with other species, common to several zones and widely disseminated over southwestern or western North America.

This mix-up of faunal zones is not limited to the level grasslands nor deserts but occurs also in the proximity of, and in, the mountainous regions. Here faunas are superimposed altitudinally and the boundaries of one intermingle with those of higher elevations while their lower margins merge with those from lower altitudes, whether of grassland or desert. We find that the analysis of such a conglomeration of species is not an easy matter, but one requiring much study, especially of the actual geographical distribution of each individual species.

On the semi-arid grasslands of the Southwest it is impossible to determine whether three species dwelling side by side are members of the same fauna or representative of three different faunae, each originating or having its optimum zone in a different region, such as: one from the Great Plains region, another from the Southwestern Grasslands and the third of Mexican origin. They dwell together because their habitat represents the common meeting ground of different faunae, and only an exhaustive study would reveal whether or not that particular region is part of their area of optimum distribution.

Faunal zones and faunal regions are man-made designations in which groups of animals are placed if the members have the same range of environmental requirements. These divisions therefore indicate the adaptations of a particular species or group of species to their environment. The capacity of each to meet either a narrow or broad range in climatic and food conditions determines their potentialities for reproduction and dispersal, which is of course the basis of distribution. The species by its own selection of the factors most favorable to its life processes naturally indicates the faunal region or zone or fauna to which it belongs. The arduous task is the correct interpretation by man of the natural phenomena involved. What to one worker may seem a feasible and plausible explanation may to another appear unwieldy or incorrect. It is hoped that the writer's analyses may prove correct despite the paucity of our knowledge concerning most species.

This study of the orthopteran faunal zones of the Big Bend Region of Trans-Pecos Texas has revealed the following subdivisions or faunae of the Lower and Upper and Transition Zones found in the Southwestern United States. The writer has used the term *fauna* to designate the subdivision of a zone. Naturally all members or species of a single fauna bear a closer relationship to each other than do other members of a zone or zones. However, one

must remember that the individuality of each species prevents a minute comparison of the biological and ecological characteristics of one species with another in the same fauna. In general, however, we can say that the species of a certain fauna have in common: the same general distribution, the same temperature preferences and the same general response to climatic conditions; but their choice of habitat and food plants need not necessarily be the same—they are often diverse.

The faunae of the various Zones are briefly summarized below:

AUSTRAL FAUNAL REGION

A. LOWER SONORAN ZONE

a. *Lower Sonoran Fauna.*—The range of the species of this fauna is determined by the distribution of the creosote plant (*Larrea divaricata*) which characterizes the desert regions of the Southwest. This region includes the Pecos, Otero and Rio Grande valleys of Trans-Pecos Texas and New Mexico, southwestern and western Arizona, the southwestern tip of Utah, southern Nevada and southeastern California. In Mexico it includes western Sonora, Baja California, Coahuila, Nuevo Leon and part of Zacatecas.

b. *Mexican Lower Sonoran Fauna.*—A fauna peculiar to the mountainous regions of northeastern Mexico whose northern limits of distribution are found in the southern portions of the Big Bend Region of Trans-Pecos Texas and also in south central Arizona. The range of the members of this fauna are more coextensive than that of the following group.

c. *Chihuahuan Lower Sonoran Fauna.*—This fauna is indigenous to the Chihuahuan or eastern desert tract of North America. It is found only east of the Continental Divide and is largely restricted to Trans-Pecos Texas but its northern limits extend beyond that found in the Mexican Lower Sonoran fauna. In Mexico this fauna is found in Coahuila and western Nuevo Leon.

B. UPPER SONORAN ZONE

a. *Mexican Upper Sonoran Fauna.*—This Upper Sonoran fauna of Mexican origin is known in the United States only from the Chinati Mts. of Trans-Pecos Texas and certain mountain ranges of south central Arizona such as the Baboquivari, Tumacacori, and Santa Ritas. The altitudinal range of this fauna extends generally between 4500 and 5500 feet. This fauna ranges far south into Mexico.

b. *Chihuahuan Upper Sonoran Fauna.*—This Upper Sonoran fauna is peculiar to Trans-Pecos Texas and the northeastern Mexican states of Coahuila and western Nuevo Leon. It is found generally at altitudes ranging from 4500 to 6000 feet and its northern limits range well north of that area occupied by the Mexican Upper Sonoran fauna.

c. *Southwestern Grasslands Fauna.*—This fauna is composed of a large number of grassland species inhabiting the Southwestern Grasslands whose range extends generally from southeastern Arizona to the Big Bend Region of Trans-Pecos Texas and north over New Mexico to southeastern Colorado and southwestern Kansas and sometimes north to extreme southwestern Nebraska. In Mexico this fauna ranges south over the Highland plateau, at appropriate elevations of 5000 to 6000 feet, to Zacatecas.

d. *Southern Short Grasslands Fauna.*—This large group of species has considerably more latitude in distribution than those of the Southwestern Grasslands fauna due principally to a greater range in tolerance to the climatic conditions existing in the Southwest. Their distribution covers the general area of the Southwest occupied by the Southwestern Grasslands fauna, but on the Great Plains

their range extends north between the Rocky Mountains and the western portions of Kansas, Nebraska and South Dakota to southwestern North Dakota (west of the Missouri), the eastern portion of Montana to the Milk River Valley of extreme southeastern Alberta.

C. TRANSITION FAUNAL ZONE

a. *Northern Short Grasslands Fauna.*—Members of this fauna have a temperature preference slightly lower than those of the Southern Short Grasslands Fauna and hence in the Southwest are found at higher altitudes of 5500 to 6500 feet on the grasslands adjacent to and extending throughout the Davis Mountains and similar ranges of the Southwest. Further north the members of this fauna are common plains species extending their range to the Canadian Prairie Provinces and occupying much of the area between the Rocky Mountains and the Mississippi Valley as far south as northern Oklahoma.

b. *Southwestern Mountain Transition Fauna.*—This fauna is composed of a small group of species found at altitudes ranging from 5500 to 7500 feet elevation in the mountainous regions of Trans-Pecos Texas, New Mexico and eastern Arizona. Many species are associated with the more forested areas of that region.

The Orthoptera, especially the Acrididae or grasshoppers, are undoubtedly the finest known indicators of insect faunal regions and zones. Not only are they of relatively large size and comparatively few in number of species but they are rich in numbers of individuals of each species and further their terrestrial habits make them rather "autochthonous," that is, we can be reasonably certain, with few exceptions, that a grasshopper taken in a certain type of environment, be it mountain peak, grasslands or desert, is a product of that particular type of habitat. In other words we can be sure that the eggs of a certain acridid species were laid in that same environment in which the young hoppers developed to maturity. Furthermore, the *direct metamorphosis* of acridid from eggs to nymph which reaches maturity by a series of successive molts has many advantageous factors. It not only simplifies the matter of habitat and food (the young eat the same plants as the adults) but it also presents a simpler and more constant habitat picture than do insects such as butterflies, beetles, bees, wasps and dragonflies with their indirect metamorphoses. In addition grasshoppers are not only the product of their environment for one particular season but are time-products of their habitats for hundreds and thousands of years. Not only are they terrestrial and feed on the earth's common coverage, grasses of the plains and shrubs and grasses of the desert, but many species are brachypterous and flightless and therefore confined to a given habitat. Even the winged species are sedentary and non-migratory, with the exception of the Rocky Mountain Locust (*Melanoplus m. mexicanus*) which migrates in drought years. Incidentally, the species of locusts which possess both solitary and migratory phases number less than ten for the entire world. On the other hand it is a matter of conjecture how far a butterfly, moth, bee, wasp, beetle or dragonfly has wandered and flown before being captured. Butterflies and moths are frequently observed migrating.

Because of their terrestrial and sedentary habits, the grasshoppers are not only fine indicators of environmental conditions but their time-space distribution is an ancient and excellent one, that is, the geographic distribution of species, genera and subfamilies is a good index of the time-space factor. In

other words the geographic range of each grasshopper is an expression of a long period of time. Unfortunately man does not know how many thousands of years it has taken each species to reach the limits of its present range, but we are reasonably certain that in comparison, man's antiquity is young.

Time may show that grasshoppers may prove to be as accurate an index to faunal zones and regions as we can find among the terrestrial members of the animal kingdom. Certainly they are superior to birds with their roving habits, and they may outrank mammals, horned lizards and snails in this regard. Because they are more widespread and more common than horned lizards and

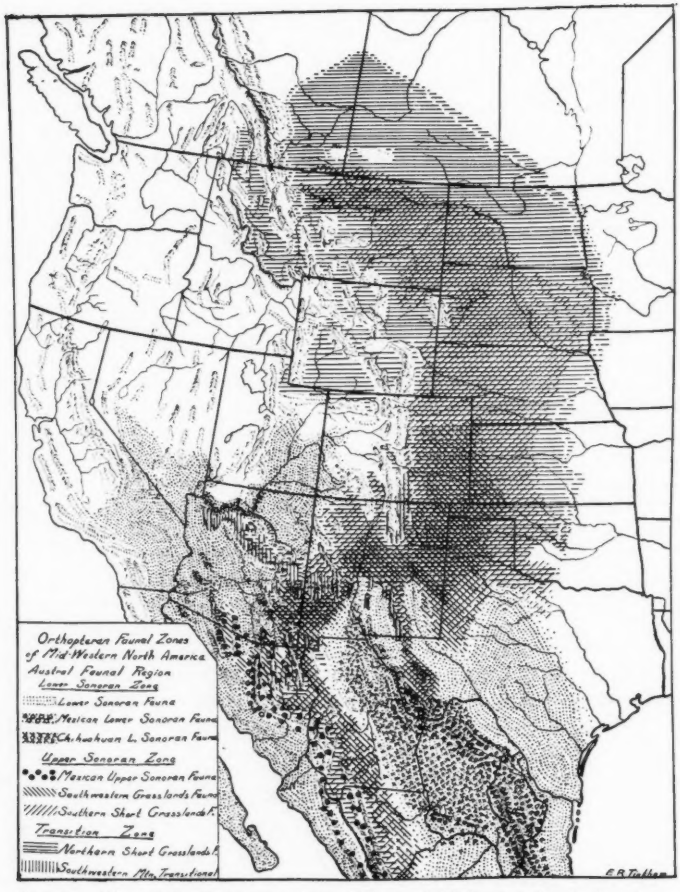


Fig. 37.—Map of the Orthopteran Faunal Zones of Midwestern North America.

snails they have certain advantages over these forms especially when considered on a world-wide basis. The comparative merits of grasshoppers *versus* mammals as faunal indicators will not be argued or discussed at this time.

From these observations the writer believes that the map of the Orthopteran Faunal Zones of Midwestern North America (Fig. 37) accurately depicts the insect faunal zones of that area since it is based on many species. Time may prove that these insect faunal zones accurately delineate those of other groups of animals and may be found more accurate than our present faunal maps (of Merriam *et al.*) which are based entirely on the normal mean temperature for the six hottest weeks of the year for southern limits and by the total quantity of heat during the period of growth and reproduction for northern limits of zonal distribution.

The accompanying map (Fig. 37) illustrates the extent of the various faunae of the Lower, Upper and Transition Zones of the Austral Faunal Region of Midwestern North America.

Below, in generic arrangement, is a list of species collected in the Big Bend Region of Trans-Pecos Texas. Several species are listed that probably in this region but which have eluded discovery to date.

Seasonal distribution, habitat and faunal designations are given for each species in as concise a manner as possible.

A Seasonal, Environmental and Faunal List of the Orthoptera of the Big Bend Region of Trans-Pecos Texas*

BLATTIDAE

BLATTINAE

Blatella germanica	annual	domiciliary	Lower & Upper Sonoran
Parcoblatta desertae	May	detritus	Lower Sonoran
Periplaneta americana	annual	domiciliary	Lower & Upper Sonoran
Supella supellectilium	annual	domiciliary	Lower & Upper Sonoran

POLYPHAGINAE

Arenivaga erratica	Aug.-Oct.	detritus	Lower Sonoran
Arenivaga grata	July-Sept.	troglodytic	Mexican U. Sonoran
Arenivaga tonkawa	Aug.-Sept.	detritus	Tamaulipan S-D. Bushland
Eremoblatta subdiaphana	May-Sept.	detritus	Lower Sonoran
Eremoblatta n. sp.	Aug.-Sept.	detritus	Chihuahuan L.S.

MANTEIDAE

AMELINAE

Litaneutria minor	July-Oct.	campestrian	S.S. Grasslands U.S.
Yersiniops solitarium	Sept.	campestrian	SW. Grasslands U.S.

OLIGONICINAE

Oligonicella scudderi	Aug.-Oct.	campestrian	SW. Grasslands U.S.

MANTEINAE

Stagmomantis californica	Aug.-Oct.	thamnophilous	Lower Sonoran
Stagmomantis limbata	Aug.-Oct.	thamnophilous	Lower Sonoran

* An asterisk indicates the first American record north of Mexico; a dagger denotes the first records east of Arizona; a double dagger indicates a first Texas record; a section mark indicates species new to science discovered by the writer.

PHASMIDAE			
Parabacillus coloradus	Aug--Oct.	campestrian	Upper Sonoran
HETERONEMIAE			
Diapheromera covilleae	July-Oct.	thamnophilous	Chihuahuan L.S.
Diapheromera femorata	Aug.-Oct.	arboreal	Upper Sonoran
Diapheromera velii eucnemis	July-Sept.	thamnophilous	Chihuahuan L.S.
Diapheromera torquata	July-Oct.	thamnophilous	Chihuahuan L.S.
Megaphasma denticrus	Sept.-Oct.	thamnophilous	Austroriparian
Pseudosermyle straminea	Aug.-Oct.	campestrian	L. & U.Sonoran
TETRIGIDAE			
Paratettix a. aztecus	Jan., Jul.-Sept.	wet soil nr streams	L. & U. Sonoran
Paratettix m. mexicanus	Sept.-Oct.	wet soil	Lower Sonoran
ACRIDIDAE			
ACRIDINAE			
Achurum sumichrasti	early June	campestrian (tall)	Mexican U. Sonoran
Eremiacris virgata	Sept.-Oct.	campestrian (tall)	SW. Grasslands U. S.
Mermiria neomexicana	late July-Nov.	campestrian	L. & U.Sonoran
Mermiria texana	Sept.-Oct.	wet soil nr streams	U. pt. U. Sonoran
Bootettix argentatus	annual	thamnophilous (*Larrea*)	Chihuahuan L. S.
Pedioscirtetes maculipennis	July-Sept.	saxi-campestrian	Chihuahuan L. S.
Acrolophitus variegatus	June-Sept.	saxi-campestrian	SW. Grasslands U.S.
Syrbula fuscovittata	Aug.-Oct.	campestrian	SW. Grasslands U.S.
Syrbula admirabilis ?	Aug.-Oct.	campestrian	Upper S. (humid)
Opeia imperfecta	late June-Oct.	campestrian	SW. Grasslands U.S.
†*Amblytropidea mysteca*	May-early Jul.	campestrian (tall)	Mexican U. Sonoran
Amphitornus coloradus ?	July-Sept.	campestrian	N. Short Grlands Transit.
Eritettix variabilis	May-July	campestrian	SW. Grasslands U. S.
Phlibostroma 4-maculata	Sept.-Oct.	campestrian	N. Short Grlands Transit.
Cordillacris o. occipitalis	June-July	campestrian	S. Short Grasslands U. S.
Cordillacris c. crenulata	June-July	campestrian	S. S. Grasslands U. S.
Orphulella p. deserta	June-Aug.	campestrian	Humid U. & L. Sonoran
Acantherus piperatus	Aug.-Oct.	campestrian	Mexican L. Sonoran
Ageneotettix d. deorum	July-Oct.	campestrian	N. Short Grasslands T.
Psoloessa t. pusilla (atyp)	May-Sept.	campestrian	U. Sonoran, L. S. (pt.)
Psoloessa d. delicatula	May-June	campestrian (tall)	N. S. Grasslands & U. S.
†*Rhammatocerus v. viatoria*	Apr.-May	campestrian (tall)	Mexican U. Sonoran
Boopedon nubilum	Sept.-Oct.	campestrian	S. S. Grasslands U. S.
**Zapata brevipennis*	Sept.-Oct	deserticolous	Mexican L. Sonoran
‡*Heliaula rufa*	July-Oct.	saxi-campestrian	SW. Grasslands U. S.
Drepanopterna femoratum	July-Oct.	campestrian	S. Short Grasslands
Aulocare elliotti	June-Oct.	campestrian	N. S. Grasslands T.
Goniatron planum	July-Oct.	thamnophilous	Chihuahuan L. S.
OEDIPODINAE			
Arphia crassa	Sept.-Oct.	campestrian (tall)	SW. Grasslands U. S.
Arphia aberrans	April-May	deserticolous	L. & U. Sonoran
Encoptolophus subgracilis	June-Oct.	campestrian (cul.)	L. Sonoran
Hippiscus rugosus	Sept.-Oct.	tall campestrian & oak sylvan	U. S. & Humid Carolinian
Xanthippus c. pantherinus	May-June	campestrian	SW. Grasslands U. S.
Leprus cyaneus	July-Oct.	campestrian (tall)	SW. Mtn. Transition
Leprus wheeleri	Aug.-Oct.	campestrian (tall)	Upper Sonoran
Tropidolophus formosus	Sept.-Oct.	on malvas	SW. Grasslands U. S.
Dissosteira carolina	July	terricolous (dust)	N. Short Grasslands T.
Dissosteira longipennis	July-Oct.	campestrian (tall)	S. Short Grasslands U. S.
Spharagemon b. inornatum	Sept.-Oct.	oak sylvan	SW. Mtn. Transition
Spharagemon c. cristatum	May-Oct.	arenicolous	Lower Sonoran
Platylactista aztecus	June-Oct.	des.-campestrian	Lower Sonoran
Derotmema h. mesembrinum	June-Oct.	terricolous	Chihuahuan L. S.
Trachyrhachis k. fuscifrons	Aug.-Oct.	campestrian	SW. Grasslands U. S.
Trachyrhachis aspera	Sept.-Oct.	campestrian	SW. Mtn. Transition
Rehnita capito	June-Sept.	des.-campestrian	SW. Grasslands U. S.
Mestobregma p. corrugatum	June-Sept.	campestrian	SW. Grasslands U. S.
Mestobregma terricolor	Aug.-Oct.	terricolous	Lower Sonoran

Trimerotropis texana	July-Sept.	saxi-arenicolous	Chihuahuan Lower S.
‡*Trimerotropis cyaneipennis*	Sept.-Oct.	semi-sylvan(mtn.)	SW. Mtn. Transition
Trimerotropis p. pallidipennis	annual	derserticolous	L. & U. Sonoran
Trimerotropis citrina	June-Oct.	arenicolous	Austroriparian
‡*Trimerotropis strenua*	July-Oct.	deserticolous	Lower Sonoran
Trimerotropis pistrinaria	July-Oct.	deserticolous	U.S. & N. Short Grasslds.
Trimerotropis lacticincta	July-Oct.	campestrian	SW. Grasslands U. S.
Trimerotropis latifasciata	Aug.-Oct.	deserticolous	Lower Sonoran
Trimerotropis melanoptera	Aug.-Oct.	campestrian (tall)	SW. Grasslands U. S.
Trimerotropis magnifica	July-Oct.	campestrian (tall)	SW. Grasslands U. S.
Hadrotettix trifasciatus	July-Oct.	saxi-campestrian	N. Short Grasslands
Anconia hebardi	Apr.-May	saxi-arenicolous	Chihuahuan L. S.
Cibolacris p. aridus	May-Nov.	saxicolous	Lower Sonoran
‡*Heliastus benjamini*	Sept.-Oct.	saxicolous	Mexican U. S.

PAMPHAGINAE

Phrynotettix robustus	May-Nov.	deserticolous	Chihuahuan L. S.
Phrynotettix tschivavensis	June-Oct.	saxi-campestrian	Chihuahuan U. S.

ROMALEINAE

Brachystola magna	Sept.-Nov.	campestrian	S.Short Grasslands U. S.
Taeniopoda eques	Sept.-Nov.	thamnophilous	L. Sonoran (restricted)

CYRTACANTHACRINAE

†*Clematodes larreae*	May-Nov.	thamnophilous	Mexican L. S.
Schistocerca v. vaga	Sept.-May	d.-thamnophilous	L. Sonoran
Schistocerca a. americana	June-Dec.	campestrian (tall)	Austroriparian
Schistocerca shoshone	Aug.-Nov.	thamnophilous	Upper Sonoran
Schistocerca lineata	Sept.-Nov.	semi-oak-sylvan	N. Short Grasslands T.
§*Schistocerca chinatiensis* n. sp.	Sept.-Nov.	thamnophilous	Chihuahuan U.S.
**Netrosoma nigropleura*	Sept.-Nov.	des.-campestrian	Chihuahuan L. S.
**Philocleon nigrovittata*	July-Nov.	des.-campestrian	Tamaulipan S-D Bushland
Phaedrotettix d. palmeri	Aug.-Oct.	campestrian	Chihuahuan U. S.
Phaulotettix eurycercus	Aug.-Nov.	thamnophilous	Chihuahuan L. S.
Agroecotettix m. crypsidomus	July-Nov.	thamnophilous	Chihuahuan U. S.
Camplycantha o. vivax	July-Nov.	thamnophilous	Chihuahuan L. S.
Aeoloplus elegans	June-Sept.	thamnophilous	Chihuahuan L. S.
Hesperotettix v. viridis	June-Oct.	thamnophilous	SW. Grasslands U. S.
Melanoplus aridus	June-Oct.	thamnophilous	L. S., U. S., Transition
‡*Melanoplus desultorius*	Aug.-Nov.	campestrian	SW. Grasslands U. S.
Melanoplus glaucipes	July-Nov.	thamnophilous	U. S. (humid)
Melanoplus thomasi	Sept.-Nov.	campestrian	SW. Grasslands U. S.
Melanoplus d. nigricans	Sept.-Nov.	forage crops	L. S., U. S. (cultivated)
Melanoplus lakinus	July-Nov.	campestrian	S. Short Grassland U. S.
Melanoplus eumera	Aug.-Nov.	campestrian (tall)	Chihuahuan U. S.
Melanoplus gladstoni	Sept.-Nov.	campestrian	N. St. Grasslands Trans.
Melanoplus arizonae	July-Nov.	campestrian	SW. Grasslands U. S.
Melanoplus regalis	July-Oct.	campestrian	SW. Grasslands U. S.
Melanoplus o. occidentalis	June-Oct.	campestrian	S. Short Grasslands U. S.
Melanoplus herbaceus?	July-Oct.	thamnophilous	Lower Sonoran
Melanoplus f. elongatus	July-Oct.	thamnophilous	Upper Sonoran?
Melanoplus b. propinquus	July-Oct.	thamnophilous	Lower Sonoran
Melanoplus f-r. femur-rubrum?	July-Dec.	campestrian	Transition
Melanoplus m. mexicanus?	July-Nov.	campestrian	Transition & Boreal
Photaliotes nebrascensis	Aug.-Nov.	campestrian	N. Short Grasslands T.
Dactylotum variegatum	July-Oct.	des.-campestrian	Upper Sonoran

TETTIGONIIDAE

PHANEROTROPINAE

Dichopetala oreoeca	Sept.-Oct.	thamnophilius	Chihuahuan U. S.
Dichopetala brevihastata	July-Oct.	thamnophilius	Chihuahuan L. S.
Arethaea semialata	Sept.-Oct.	thamnophilius	Chihuahuan U. S.
Arethaea arachnopyga	Sept.-Oct.	thamnophilius	Chihuahuan U. S.
§*Arethaea g. cerciata*	Sept.-Oct.	thamnophilius	Chihuahuan U. S.
Insara e. elegans	June-Oct.	thamnophilius	Lower Sonoran
Scudderia f. furcifera	Aug.-Nov.	thamnophilius	L. & U. Sonoran
Amblycorypha huasteca	Aug.-Oct.	thamnophilius	Lower Sonoran(humid)
Amblycoryhpa insolita	Aug.-Oct.	thamnophilius	Mexican Upper Sonoran
Microcentrum rhombifolium	Aug.-Nov.	arboreal	Lower Sonoran

	PSEUDOPHYLLINAE		
Paracyrtophyllus excelsus	July-Oct.	arboreal (oaks)	Chihuahuan U. S.
	COPIPHORINAE		
Neoconcephalus r. crepitans	Sept.-Nov.	campestrian (tall)	Upper Sonoran (humid)
Neoconocephalus triops?	Sept.-May	thamnophilous	Lower Sonoran
	CONOCEPHALINAE		
Orchelimum c. concinnum	Aug.-Nov.	thamnophilous	Upper Sonoran (humid)
Conocephalus strictus	Aug.-Oct.	campestrian (tall)	Upper Sonoran
Conocephalus f. fasciatus?	Aug.-Oct.	campestrian	Transitional
	DECTICINAE		
Capnobotes fuliginosus	July-Oct.	thamnophilous	Lower Sonoran
Rehnia cerberus	Sept.-Nov.	thamnophilous	Chihuahuan L. S.
Rehnia victoriae	Aug.-Oct.	thamnophilous	Tamaulipan S-D Bushland
§*Pediodectes tinkhami*	Aug.-Oct.	deserticolous	Chihuahuan L. S.
Pediodectes bruneri	Sept.-Nov.	campestrian (tall)	Upper Sonoran (humid)
Eremopedes scudderi	July-Nov.	thamnophilous	Chihuahuan L. S.
§*Eremopedes covilleae*	July-Oct.	thamnophilous	Chihuahuan L. S.
	GRYLLACRIDIDAE		
	RHAPHIDOPHORINAE		
Ceuthophilus variegatus	July-Oct.	deserticolous	Chihuahuan L. S.
Ceuthophilus pallidus	Aug.-Oct.	terricolous	N. Short Grasslands T.
Ceuthophilus isletae	Sept.-Oct.	troglodytic	SW. Mtn. Transition
Ceuthophilus rehni	Aug.-Oct.	troglodytic	Chihuahuan U. S.
Ceuthophilus polingi	Sept.-Oct.	troglodytic	Chihuahuan U. S.
Ceuthophilus carlsbadensis	Sept.-Jan.	cavernicolous	Chihuahuan U. S.?
§*Ceuthophilus utahensis*	Sept.-Oct.	troglodytic	SW, Mtn. Transition
Ceuthophilus conicaudus	Sept.-Oct.	troglodytic	?
	GRYLLULIDAE		
	GRYLLULINAE		
Gryllulus assimilis	July-Oct.	des.-campestrian	L. & U. S. & Trans.
Miogryllus lineatus?	Aug.-Oct.	campestrian	Lower Sonoran
	NEMOBIINAE		
Nemobius c. neomexicanus	Aug.-Oct.	campestrian	Lower and U. Sonoran
N. cubensis mormonius?	Aug.-Oct.	campestrian	Lower Sonoran
	OECANTHINAE		
Oecanthus californicus	Sept.-Oct.	thamnophilous	Lower Sonoran
Oecanthus sp.	Sept.-Oct.	thamnophilous	Lower Sonoran
	MOGOPLISTINAE		
Cycloptilum c. fortior	Aug.-Oct.	thamnophilous	Lower Sonoran
Cycloptilum c. comprehendens	Aug.-Oct.	thamnophilous	Upper Sonoran (humid)
Haplosphyrum boreale	Sept.-Nov.	troglodytic	Lower Sonoran

Conclusions

The above list of one hundred and fifty known species and of nine additional species that should be found, testify to the remarkable orthopteran fauna that has developed in the Big Bend Region of Trans-Pecos Texas. This is due to the geographical setting of the Big Bend Region which is so situated that the Davis Range with its grassy valleys on the north has much the same faunal elements as the Great Plains and the Rocky Mountain region to the north while the Chisos Mountains show a strong influx of more eastern species which reach their western limits of distribution on the eastern border of the Big Bend in eastern Brewster County and the Chisos. The Chinati Mountains in the southern part of Presidio County and at least 75 miles northwest of the Chisos, due to their different floristic features and limestone formation, possess elements of a Mexi-

can Lower Sonoran fauna not found elsewhere in the entire United States. In addition the Chinatis have representatives of a Mexican Upper Sonoran fauna found for the first time east of south-central Arizona. The result is an area exhibiting interwoven and superimposed faunae that make this Big Bend Region of Trans-Pecos Texas one of the richest and most remarkable in the United States.

This entire treatise has been graphically condensed into a faunistic-floristic transect of Presidio and Jeff Davis counties which is presented in the body of this report (Fig. 23). This transect represents a 100 mile section running from the Rio Grande Valley at Presidio, across the Chinati Mountains and the Marfa grasslands of Presidio County to the northern slopes of Mt. Livermore of the Davis Mountains in Jeff Davis County. On this transect graph the vegetational types of the Big Bend Region are roughly typified by certain designated symbols which are used to indicate the various floral types upon which the faunal zones and their component faunae are based. It was not deemed necessary to produce a similar transect crossing the Chisos Mountains northward through Brewster County.

In the summary a map of the Orthopteran faunal zones of Midwestern North America presents in a geographical plane the composite distribution of the various zones and faunae as depicted in the faunistic-floristic transect of this region.

Careful notes on the biology, habit, song, and host plant of each orthopteran species have been presented whenever possible.

A detailed study of each individual species of Orthoptera, its biology and zoogeography, has made it possible to assign most of the 150 species of Big Bend Orthoptera to the various faunae characterizing and composing the Lower and Upper Sonoran and Transition Faunal Zones of the Austral Faunal Region of Midwestern North America.

It is hoped that this contribution, the result of several years collecting and further years of study, preparation and writing, will fill a gap in our knowledge of one of the largest and most remarkable, yet little known areas, of the Southwestern desert regions.

REFERENCES

ALEXANDER, GORDON 1941—Keys for the identification of Colorado Orthoptera. Univ. of Colo. Studies, Series D, 1(3): 129-164, 4 figs.

BALL, E. D., E. R. TINKHAM, ROBERT FLOCK AND C. T. VORHIES 1942—The Grasshoppers and other Orthoptera of Arizona. Univ. of Ariz., Tech. Bull. 93: 257-373, pls. I-IV, 11 figs. (93 illus.).

BEAMER, RAYMOND 1917—The grasshoppers of Kansas: Part II. The Oedipodinae of Kansas. Bull. Univ. Kansas, Biol. Ser., 18: 51-126, illus.

BENSON, LYMAN 1941—The mesquite and screw-beans of the United States. Amer. Jour. Bot., 28: 748-754, map, 1 pl.

BIBBY, F. F. 1931—Coccoids collected on wild plants in semi-arid regions of Texas and Mexico (Homoptera). Jour. N. Y. Ent. Soc., vol. 39.

BUCKELL, E. R. 1922—British Columbia Orthoptera. Proc. Ent. Soc. Br. Col., No. 20, Syst. Ser., 12-41.

———1924—Additions and corrections to the list of British Columbia Orthoptera. Proc. Ent .Soc. Br. Col., 22: 7-12.

CARTER, W. T. AND V. L. CORY 1930-31—Soils of Trans-Pecos Texas and some of their Vegetative relations. Trans. Texas Acad. Sci., 15: 19-37.

CAUDELL, A. N. 1903—Two Orthoptera hitherto unrecorded from the United States. Proc. U. S. Nat. Mus., no. 1378, 27: 949-952.

———1904—Orthoptera from Southwestern Texas. Mus. Brookl. Inst. Arts and Sci., Bull., 1: 105-116, 6 pls.

———1907—The Decticinae of North America. Proc. U. S. Nat. Mus., no. 1530, 32: 285-410.

CORY, V. L. 1930—Contributions to the family Liliaceae. Bull. Sul Ross State Teachers College. No. 3: 32-36.

COTTLE, H. J. 1931—Studies in the Vegetation of Southwestern Texas. Ecology, 12(1): 105-156, 47 figs.

DUNCAN, CARL D. 1924—Spiracles as sound producing organs. Pan. Pac. Ent., 1: 42-42.

FLETCHER, HENRY T. 1928—Notes on the vegetation of the Green Valley region. Bull. Sul Ross State Teachers College. No. 2: 6-49.

———1930—Notes on the Ethnobotany of Bee Canyon. Ibid., No. 3: 37-44.

FOX, HENRY 1917—Field notes on Virginia Orthoptera. Proc. U. S. Nat. Mus., no. 2176, 52: 199-234.

GURNEY, A. B. 1940—A revision of the grasshoppers of the genus *Orphulella* Giglio-Tos from America north of Mexico (Orthoptera: Acrididae). Ent. Amer., 20: 85-157, illus.

HEBARD, MORGAN 1917—Notes on Mexican Melanopli (Orth.; Acrididae). Proc. Acad. Nat. Sci. Phila., 79: 251-257.

———1918—New Genera and Species of Melanopli found within the United States (Orth.; Acrididae). Trans. Amer. Ent. Soc., 44: 141-169.

———1919—New Genera and Species of Melanopli found within the United States (Orth.; Acrididae). Part II. Ibid., 45: 257-298.

———1920—Revisionary studies in the genus *Arenivaga* (Orth.; Blatt.; Polyphaginae). Ibid., 46: 197-217.

———1922a—New Genera and Species of Melanopli found within the United States (Orth.; Acrididae). Part III. Ibid., 46: 355-403.

———1922b—New Genera and Species of Melanopli found within the United States and Canada (Orth.; Acrididae). Part IV. Ibid., 48: 49-66.

———1922c—North American Acrididae (Orthoptera). Papers 1 & 2. Ibid., 48: 89-108.

———1922d—Dermaptera and Orthoptera from the state of Sinaloa, Mexico. I (Derm.; and non-Saltatorial Orth.). Ibid., 48: 157-196.

———1923—North American Acrididae (Orthoptera). 3. A study of the Ligurotettigi. Ibid., 49: 43-92, pls. 6-7.

———1924—The group Scyllinae as found in North America with records and data on its occurrence in the United States (Orth.). Ibid., 50: 157-165.

———1924b—A revision of the genus *Taenipoda* (Orth.; Acrididae; Cyrtacanthacrinae). Ibid., 50: 253-274.

———1925a—The group Taeniopodae as found in the United States (Orth.). Ibid., 51: 1-12.

———1925b—The Orthoptera of South Dakota. Proc. Acad. Nat. Sci. Phila., 77: 33-155.

———1925c—Dermaptera and Orthoptera from the state of Sinaloa, Mexico. 2. Saltatorial Orthoptera. Trans. Amer. Ent. Soc., 51: 265-310.

———1926—Key to the North American genera of the Acridinae which occur north of Mexico (Orth.; Acrididae). Ibid., 52: 47-59.

———1928—The Orthoptera of Montana. Proc. Acad. Nat. Sci. Phila., 80: 211-306.

———1929—The Orthoptera of Colorado. Ibid., 81: 303-425.

———1930—The Orthoptera of Alberta. Ibid., 82: 377-403.

———1931a—The Orthoptera of Kansas. Ibid., 83: 119-227.

———1931b—Studies in Lower California Orthoptera. Trans. Amer. Ent. Soc., 57: 113-127.

———1931c—The races of *Diapheromera velii* (Orth.; Phasmidae; Heteronemiinae). Ent. News, 42: 65-67.

———1931d—The Mogoplistinae of the United States (Orth.; Gryllidae). Trans. Amer. Ent. Soc., 57: 135-160.

———1932a—The Orthoptera of Minnesota. Univ. Minn. Agric. Exp. Sta. Tech. Bull. 85: 1-611.

———1932b—New species and records of Mexican Orthoptera. Trans. Amer. Ent. Soc., 58: 201-371, pls. 17-22.

———1932c—Notes on Montana Orthoptera. Proc. Acad. Nat. Sci. Phila., 84: 251-257.

———1934a—The Dermaptera and Orthoptera of Illinois. Ill. State Nat. Hist. Surv. Bull., 20: 125-279, illus.

———1934b—Studies in Orthoptera which occur in North America North of the Mexican Boundary. III. Revisionary Data and new North American Decticinae. Trans. Amer. Ent. Soc., 60: 31-54, pls. 2-3.

———1935a—Orthoptera of the upper Rio Grande Valley and the adjacent mountains in northern New Mexico. Proc. Acad. Nat. Sci. Phila., 87: 45-82.

———1935b—Studies in the Orthoptera of Arizona. I. New genera, species and races. Trans. Amer. Ent. Soc., 61: 111-153, pls. 4-7.

———1935c—Studies in the Orthoptera of Arizona. II. A list of the Dermaptera and Orthoptera with new records and corrections of the literature subsequent to 1909. Ibid., 61: 269-316.

———1936a—Studies in Orthoptera which occur in North America north of the Mexican Boundary. 6. Revision of the genus *Arethaea* (Tettigoniidae: Phanerotropinae). Ibid., 62: 231-256, illus.

———1936b—The Orthoptera of North Dakota. North Dakota Agric. Exp. Sta. Tech. Bull. 284: 1-69.

———1937—Studies in Orthoptera which occur in North America north of the Mexican boundary. 9. On *Arphia conspersa*, notes and a new species of *Spharagemon*, a new genus and its races of the group Heliasti and a new generic name for the group Anconiae (Oedipodinae, Acrididae). Trans. Amer. Ent. Soc., 63: 361-379, pls. 12-13.

———1939—An ecological survey of the Orthoptera of Oklahoma. Okla. Agric. Exp. Sta. Tech. Bull. 5: 1-31.

———1941—The group Pterophyllae as found in the United States (Orthoptera: Tettigoniidae). Trans. Amer. Ent. Soc., 67: 197-319, pls. 18-19.

———1943—The Dermaptera and orthopterous families Blattidae, Mantidae and Phasmidae of Texas. Ibid., 68: 239-311, pls. 12-13.

HENDERSON, W. W. 1924—A taxonomic and ecological study of the species of the subfamily Oedipodinae (Orth.; Acrididae) found in Utah with a summary of world distribution and a list of Orthoptera recorded from the state. Utah Agric. Exp. Sta. Tech. Bull. 191, 150 pp., illus.

———1931—Crickets and Grasshoppers in Utah. Utah Agric. Exp. Sta. Cir. 96, 37 pp., illus.

HINCKLEY, L. C. 1944—The Vegetation of the Mount Livermore area in Texas. Amer. Midl. Nat. 32(1): 236-250, 5 figs.

HITCHCOCK, A. S. 1935—Manual of the Grasses of the United States. U. S. Dept. Agric. Misc. Publ. 200.

HUBBELL, T. H. 1922—The Dermaptera and Orthoptera of Berrien County, Michigan. Univ. Mich. Occas. Papers, Mus. Zool., no. 116.

———1936—A monographic revision of the genus Ceuthophilus. Univ. Fla. Publ. vol. 2, no. 1, 551 pp., illus.

HUBBELL, T. H. AND A. I. ORTENBURGER 1926—Notes on Oklahoma Orthoptera with a list of species from the state. Proc. Okla. Acad. Sci., 6: 149-183.

ISELY, F. B. 1937—Seasonal succession, soil relations, numbers, and regional distribution of northeastern Texas acridians. Ecol. Monogr. 7: 318-344.

———1938—The relations of Texas Acrididae to plants and soil. Ecol. Monogr. 8: 551-604.

MCNEILL, Jerome 1901—Revision of the Orthopterous genus *Trimerotropis*. Proc. U. S. Nat. Mus., 23: 393-450, no. 1215.

PARKER, J. R. 1930—Some effects of temperature and moisture upon *Melanoplus mexicanus* Saussure and *Camnula pellucida* Scudder (Orthoptera). Montana Agric. Exp. Sta. Bull. 223: 1-132.

REHN, JAMES, A. G. 1904a—Notes on Orthoptera from northern and central Mexico. Proc. Acad. Nat. Sci. Phila., 56: 513-549.

———1904b—Notes on Orthoptera from Arizona, New Mexico and Colorado. Ibid., 56: 562-575.

———1907—Notes on Orthoptera from southern Arizona with descriptions of new species. Ibid., 59: 24-81.

———1919—Descriptions of new and critical notes upon previously known forms of North American Oedipodinae (Orth.; Acrididae). First Paper. Trans. Amer. Ent. Soc., 45: 229-255, pl. 26, col. pl. 27.

———1942—On the locust genus *Psoloessa* (Orth.; Acrid.; Acridinae). Trans. Amer. Ent. Soc., 68: 167-237, illus.

REHN, JAMES, A. G. AND HEBARD MORGAN 1906—A contribution ot the knowledge of the Orthoptera of Montana, Yellowstone Park, Utah and Colorado. Proc. Acad. Nat. Sci. Phila., 58: 358-418.

———1908—An orthopterological reconnoissance of the southwestern United States. I. Arizona. Ibid., 60: 365-402.

———1909a—An orthopterological reconnoissance of the southwestern United States. II. New Mexico and western Texas. Ibid., 61: 111-175.

———1909b—An orthopterological reconnoissance of the southwestern United States. III. California and Nevada. Ibid., 61: 409-483.

———1912—Fixation of single type (Lectotypic) specimens of species of North Amer-

ican Orthoptera. Ibid., 64: 60-128.

———1914—A study of the species of the genus *Dichoptela* (Orth.; Tettigoniidae). Ibid., 76: 64-160.

———1920—Descriptions of New Genera and Species of North American Decticinae (Orth.; Tettigoniidae). Trans. Amer. Ent. Soc., 46: 225-265.

———1925—Distributional notes on North American Orthoptera. Fla. Ent., 41-45.

ROBERTS, H. RADCLIFFE 1941a—A comparative study of the subfamilies of the Acrididae (Orthoptera) primarily on the basis of their phallic structures. Proc. Acad. Nat. Sci. Phila., 93: 201-246, 90 figs.

———1941b—Nomenclature in the Orthoptera concerning Genotype designations. Trans. Amer. Ent. Soc., 67: 1-34.

———1942—Two subspecies of *Melanoplus differentialis* and related new species from Mexico with discussion of their variations (Orth.; Acrididae: Crytacanthacridinae). Ibid., 68: 151-166.

SCHULTZ, ELLEN D. AND ROBERT RUNYON 1930—Texas Cacti. Texas Acad. Sci., vol. 14, 181 pp., illus.

SCUDDER, SAMUEL H. 1898—Revision of the orthopteran group Melanopli (Acrididae) with special reference to North American forms. Proc. U. S. Nat. Mus., 20: 1-421, pls. 1-26. No. 1124.

SHREVE, FORREST 1939—Observations on the vegetation of Chihuahua. Modroño 5(1): 1-13. Pls. 1-3 with 6 figs.

———1942—The desert vegetation of North America. Bot. Review, 8(4): 195-246, 1 map.

SPERRY, OMER E. 1938— A check list of the Ferns, Gymnosperms, and Flowering Plants of the proposed Big Bend National Park of Texas. Bull. Sul Ross State Teachers College, 19(4): 9-98, 1 map, 1 fig.

———1941a—Additions to the check list of plants of the proposed Big Bend Park area. Ibid., 22(1): 9-16.

———1941b—Plants of Brewster County, Texas. Ibid., 22(1): 17-60, 1 fig.

TINKHAM, ERNEST R. 1934—The Dragonfly Fauna of Presidio and Jeff Davis Counties of the Big Bend Region of Trans-Pecos Texas. Can. Ent., Oct., pp. 213-218.

———1938—Western Orthoptera attracted to light. Jour. N. Y. Ent. Soc., 46: 339-353.

———1939—Five new records and notes on Canadian Acrididae from the Higdon Ranch, southeastern Alberta. Can. Ent., 71: 121-126.

———1940—Taxonomic and Biological Studies on the Cyrtacanthacrinae of South China. Ling. Sci. Jour., 19(3): 269-382. Pls. 10-16, 13 figs.

———1941—Biological and Faunistic notes on the Cicadidae of the Big Bend Region of Trans-Pecos Texas. Jour. N. Y. Ent. Soc., 49; 165-183. Pl. VI, 3 figs. Figs. 1-2.

———1942—The rediscovery of *Anoplodusa arizonensis* (Orthoptera) Bull. Chicago Acad. Sci., 6(12): 221-227, 2 figs.

———1944—Biological, Taxonomic and Faunistic studies on the Shield-back Katydids of the North American Deserts. Amer. Midl. Nat. 31(2): 257-328, 28 figs.

UVAROV, B. P. 1943—The tribe Thrinchini of the subfamily Pamphaginae, and the interrelations of the Acridid subfamilies (Orthoptera). Trans. Roy. Ent. Soc. London, 93(1): 1-72, 73 figs.

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The Larvae of the Fungus-Growing Ants

George C. Wheeler
Department of Biology
University of North Dakota, Grand Forks

Fungus-growing ants have for many years attracted the attention of myrmecologists and other biologists because of their extremely interesting habit of cultivating fungi for food. Certain species (especially in the genus *Atta*) have received serious consideration from the economic entomologists, for they rank high among the destructive insects of the tropics. These leaf-cutters are also noticed by laymen because of their habit of making trails along which they travel while carrying in their mandibles the pieces of leaves they have cut; this habit has earned for them the name of parasol ants.

The fungus-growers belong to the tribe Attini of the subfamily Myrmecinae. This tribe musters at present nearly 300 species, subspecies and varieties which are commonly grouped in nine genera — *Myrmicocrypta, Apterostigma, Mycocepurus, Cyphomyrmex, Sericomyrmex, Trachymyrmex, Acromyrmex, Pseudoatta* and *Atta*. Some myrmecologists have at various times included *Proatta* and *Blepharidatta* in the tribe and others have elevated certain subgenera to generic rank.

The Attini are mostly restricted to the Neotropical Realm, but four genera (*Cyphomyrmex, Trachymyrmex, Acromyrmex* and *Atta*) range northward into the southern United States, while one of these (*Trachymyrmex*) is found as far north as a line running from southern Illinois to Long Island.

In this article I have described the larvae of twenty species and subspecies representing seven genera. In addition I have included all the references to attine larvae that I have been able to find in the literature.

Tribe Attini F. Smith

Larvae commonly swathed with mycelium from the fungus garden. Head on the ventral surface of the body often at a considerable distance from the anterior end. Body short, very stout, plump, bean-shaped, subreniform in profile; slightly compressed; somewhat narrowed near the middle; depth greatest at the middle and decreasing slightly and equally toward each end; ends large, subequal and broadly rounded; dorsal profile (occiput to anus) extremely long, crescentic; ventral profile (anus to gula) relatively short and concave. Anus ventral and usually at some distance in front of the posterior end; with one or two prominent lips. Vestigial legs near the posterior border of each thoracic segment. Segmentation indistinct. Spiracles 10 pairs, small, arranged in J-shaped or crescentic rows. Integument usually smooth. In most genera the body is almost naked and the few hairs are largely restricted to the ventral surface. Typically body hairs are short (0.03-0.16 mm), simple,

slender, flexous, tapering gradually to an acute tip; longest on the thorax and shortest near the anus.

Head somewhat broader than long. Genae often produced into a more or less conspicuous lobe. Antennae small to moderately large; three sensilla each. Mouth parts small. Head hairs usually sparse and concentrated on the lower part of the head below the antennae; typically simple, slightly curved and tapering gradually to an acute tip.

Labrum a thick flap or a subhemispherical lobe; very small; spinulose.

Mandibles small, short, stout and feebly sclerotized; typically with the apical portion curved medially, with the surfaces covered with sharp spinules and with a single elongate, acute apical tooth.

Maxillae reduced; mostly long, narrow and adnate to the head except for a free apical lobe; spinulose (at least in part).

Labium small, short, mostly concealed in front view; two anteriorly projecting bulges separated by a median depression; each lobe bearing typically a cluster of sensilla which represents the palp.

Bischoff, 1927, p. 122: "Eine reine Pflanzenkost dürften normalerweise nur die pilzzüchtenden Attinen ihren Larven bieten."

Forel, 1928 (Vol. I), p. 517: "The larvae of the *Att'ni* (*Myrmicinae*) like the adults are fed on the products or 'turnip cabbages' of the fungi cultivated by their ☿." (=1922, p. 136: "Les larves des *Attini* (*Myrmicinae*) sont nourries comme les adultes par les produits ou 'choux-raves' des champignons cultivés par leur ☿.")

Weber, 1945, p. 4: "The larvae and naked pupae are commonly swathed in mycelium from the fungus garden but the workers may clean them on occasion."

Wheeler and Bailey, 1920, p. 253: "A recent study by the senior author of various Attine larvae, belonging to the genera *Atta, Trachymyrmex, Cyphomyrmex, Sericomyrmex,* and *Apterostigma,* shows that their mouthparts are beautifully adapted for the methods of feeding described by Tanner and Huber. The mandibles are short, stout and acute, and except in *Apterostigma,* covered with numerous sharp spines, so that the delicate egg-shell or the thin walls of hyphal filaments or of kohlrabi spherules can be held and firmly squeezed and at the same time perforated with many small openings, thus allowing the liquid contents to be rapidly expressed and trickle into the mouth."

Wheeler, 1928, p. 201: The Attini "uniformly feed, both as larvae and adults, on the mycelium of particular fungi." The larval mouth parts are "beautifully adapted for puncturing the hyphae and imbibing their protoplasmic contents. . . . The feeding of the larvae among the Attini is quantitative, although the possibility of an administration of saliva to certain larvae and their conversion into queens as a result of such treatment, cannot be altogether excluded." (See also Wheeler, 1937, p. 50.)

Wheeler, 1937: Attine workers place "malaxated tufts of fungus bromatia within reach of the larval mouth parts" (p. 36). "The feeding habits of

both the adults and larvae are much simpler than those of many less specialized ants, because each species cultivates only a particular species of fungus and under normal conditions has no other diet. The bearing of this fact on the trophogenic hypothesis of caste determination is apparent when we consider that the larvae of all stages are scattered through the gardens and like the adults subsist only on bromatia, or hyphal swellings" (p. 46). "It is doubtful . . . whether the colony-founding mother feeds the larvae of her first brood in the same manner [as that employed in well established Attine colonies.] . . . It is more probable that the larvae of the incipient colony eat the mycelium directly and that larval feeding in this very early phase of colony development may really represent an ancient phylogenetic stage which persists throughout the life of the colony in Sericomyrmex and other primitive genera." (pp. 49-50).

KEY TO THE GENERA OF ATTINE LARVAE

1. Body hairs tapering gradually; straight, slightly curved or flexuous; with the tips unbranched 2
   Body hairs not as above ..... *Acromyrmex*
2. Head hairs numerous and uniformly distributed ..... *Atta*
   Head hairs few and mostly restricted to lower part of head 3
3. Head with conspicuous genal lobes; apical portion of mandibles curved medially 5
   Head without genal lobes; mandibles not curved 4
4. Head outline indefinite; 16 short head hairs, mandibles spinulose ..... *Myrmicocrypta*
   Head outline distinct; 10 long head hairs; mandibles with very few spinules or none ..... *Apterostigma*
5. Mandibles with two apical teeth ..... *Sericomyrmex*
   Mandibles with one apical tooth or none 6
6. With one hair on each genal lobe ..... *Cyphomyrmex*
   With several hairs on each genal lobe ..... *Trachymyrmex*

Genus MYRMICOCRYPTA F. Smith

Head near anterior end. Body nearly straight, subcylindrical, only moderately stout. Body hairs restricted to thorax and vicinity of anus. Integument of body spinulose. Head indistinctly separated from prothorax; no spinules or hairs above the level of the antennae; no genal lobes; hairs moderately long. Labrum a thick flap. Mandibles small; apical portion conical, not curved medially; spinules moderately numerous. Maxillae exposed; with very few spinules; palp and galea subconical. Labium exposed; palp subconical.

M. urichi Weber.—Plate I, figs. 1-8. Head on the ventral surface of the body near the anterior end. Body subcylindrical, moderately stout, somewhat compressed; nearly straight, but with the ends slightly curved ventrally; a slight constriction at the first abdominal segment; ends large, subequal and broadly rounded. Prothorax slightly arched (in profile) above and slightly inflated below. Terminal segment directed ventrally; anus ventral, with prominent lips. On either side of the prothorax, near the head, there is a dark-staining (with acid fushsin) structure of unknown nature and function. Segmentation indistict. Spiracles small. Body nearly naked; hairs restricted to the ventral surface, most abundant on the prothorax, with very few on the meso- and metathorax and a cluster around the anus. Body hairs short

(0.04-0.06 mm), simple, tapering, nearly straight. Integument of body with minute spinules arranged in rows to form a reticulate pattern. Head broader than long; occipital border broadly rounded; lateral and ventral boundaries indistinct; integument spinulose below the antennal level, the spinules arranged in short rows. Head hairs 16, simple, slightly curved, tapering rapidly, acute, 0.06 mm long. Antennae moderately large; each with three sensilla. Labrum very small; short and thick; spinulose. Mandibles small and feebly sclerotized; divided into two distinct parts — a stout base and a smaller acute conical apex; the anterior surface of the base is beset with many sharp spinules. Maxillae small and lobose; each with four relatively long hairs; palp a slender subconical projection with several lateral spinules, galea a subconical, spinulose protuberance. Labium subhemispherical; coarsely spinulose; a pair of spinulose lobes projecting forward from the anterior surface; with several hairs; palp a slender subconical process with several lateral spinules. (Material studied: several specimens collected in Trinidad by Dr. N. A. Weber.)

M. spinosa Weber.—Similar to *M. urichi.* (Material studied: two larvae from British Guiana.)

M. guianense Weber.—"Pupae were naked but the larvae had tufts of mycelia on their integument." (Weber, 1946, p. 129)

Genus APTEROSTIGMA Mayr

Head near anterior end. Body hairs limited to prosternum and vicinity of anus. Integument spinulose on the head and around the anus. No genal lobes. Head hairs relatively long; four above the antennal leval and six below. Mouth parts extremely small, apparently vestigial. Labrum a thick flap. Mandibles with the apical portion subconical and not curved medially; few spinules or none. Maxillae exposed; spinulose; palp and galea represented by clusters of sensilla. Labium exposed.

Wheeler and Bailey (1920, p. 253) state that the mouth parts in this genus "are beautifully adapted for the methods of feeding described by Tanner and Huber. The mandibles are short, stout and acute."

A. collare angulatum Weber.—Plate I, figs. 9-17. Head on ventral surface near anterior end. Body short, very stout, plump, bean-shaped; slightly narrowed at the middle; ends large subequal and broadly rounded; abdominal segments lengthened dorsally and shortened ventrally to such an extreme degree that the anus is ventral to the second abdominal spiracles. On either side a short, narrow, dark-staining (with acid fushsin) structure extends from the genae onto the prothorax; its nature and function unknown. Postanal lip prominent. Segmentation indistinct. Spiracles small; arranged in a J-shaped row. Body naked except for four hairs on the prosternum and a cluster around the anus. Body hairs slender, tapering, slightly curved, rather short (0.06-0.12 mm). Integument smooth except around the anus where minute spinules are arranged in short rows. Head somewhat broader than long; narrowed above, widest at the level of the labrum; occipital border short, impressed at the middle; sides strongly curved; integument furnished with

minute spinules which are grouped in short rows on the frontal and clypeal regions, but single elsewhere; gula inflated into a median ventral swelling. Head hairs sparse (10), simple, relatively long (0.2 mm). Antennae moderately large; each with three minute sensilla. Mouth parts greatly reduced. Labrum very small; short, broad and thick; rounded distally; a pair of sensilla on the anterior surface; anterior surface and distal edge furnished with papillae; posterior surface spinulose near the distal border, the spinules arranged in short transverse rows. Mandibles very small and feebly sclerotized; the relatively large base bearing a small acute conical apical tooth; no spinules. Maxillae lobose, subtriangular in anterior outline; integument with minute papillae arranged in short rows; palp represented by a cluster of several sensilla; galea represented by two sensilla on the medial surface. Labium transversely subelleptical in anterior view; on each side a paraboloidal lobe projecting anteriorly and bearing a cluster of three sensilla, which represents the palp; surface roughened with minute papillae arranged in short arcuate rows. Hypopharynx with minute papillae arranged in transverse rows. (Material studied: two larvae from Panama Canal Zone.)

A. mayri Forel.—Similar to *A. angulatum*. (Material studied: four larvae from Costa Rica.) Weber (1945, p. 35): "The larvae are heavily coated with the same type of mycelium as grows in the garden." Weber (1946, p. 137): "The larvae were covered with mycelium."

A. tramitis Weber.—Plate I, fig. 18. Resembles *A. angulatum* except in the mandibles. These are much smaller than in *angulatum*; triangular in anterior view; apical portion subconical, blunt-pointed; a few spinules on the lateral surface. (Material studied: two larvae from Panama Canal Zone.)

A. urichi Forel.—"Larvae were embedded in the mycelium." (Weber, 1946, p. 138.)

Genus CYPHOMYRMEX Mayr

Body hairs restricted to thorax, first three abdominal segments and vicinity of anus. Genal lobes moderately large, one hair on each. Head hairs relatively long. Labrum a thick flap. Mandibles with the apical portion strongly curved medially; spinules moderately numerous. Maxillary palp a subcylindrical peg; galea represented by a cluster of sensilla.

Wheeler and Bailey (1920, p. 253) state that in this genus "the mouthparts are beautifully adapted for the methods of feeding described by Tanner and Huber. The mandibles are short, stout and acute, and . . . covered with numerous sharp spines, so that the delicate egg-shell or the thin walls of hyphal filaments or of kohlrabi spherules can be held and firmly squeezed and at the same time perforated with many small openings, thus allowing the liquid contents to be rapidly expressed and trickle into the mouth."

C. rimosus Spinola.—Plate II, figs. 1-6. Head on the ventral surface of the body at a considerable distance from the anterior end. Body short, very stout, plump, bean-like; slightly compressed; ends large, subequal and broadly rounded; dorsal profile extremely long, crescentic; ventral profile relatively short and convex; a midventral triangular projection on the first abdominal

segment. Anus ventral and quite far forward; with prominent lips. Segmentation indistinct. Spiracles small; arranged in a crescentic row; diminishing progressively in size from anterior to posterior. Body nearly naked; a few hairs on the ventral surface of the six anterior segments and a cluster around the anus. Body hairs simple, short (0.03-0.07 mm), flexuous or slightly curved or straight. Head broader than long; occipital border broadly rounded; genae bulging into antero-ventral lobes; integument spinulose on clypeus and adjacent portion of front; naked except for a transverse row of eight long (0.05-0.1 mm) simple, slightly curved or flexuous hairs. Antennae moderately large; each with three sensilla. Labrum small and thick; breadth twice the length; distal outline strongly curved; anterior and posterior surfaces spinulose; posterior spinules in groups of one to four and arranged in short transverse rows. Mandibles small, short, stout, thick; feebly sclerotized; surfaces coarsely spinulose; apical portion strongly curved medially and terminating in several large sharp spinules; no apical tooth. Maxillae feebly developed; adnate to head except for a small subconical apical lobe; not spinulose; palp a cylindrical peg tipped with a rounded transparent cap; galea not peg-like but represented only by a cluster of four or five sensilla on the distal surface of the maxilla. Labium short, scarcely visible from in front; subhemispherical, covered with spinules arranged in short transverse rows; palp represented by a cluster of four or five sensilla on the distal surface. (Material studied: several specimens from Panama.)

Young Larva. Plate II, fig. 3. Length 0.62 mm. Head relatively very large; on the ventral surface near the anterior end. Posterior end of body bent ventrally at right angles and forming an obtuse conoid with the anus on its anterior surface. Remainder of body straight and subcylindrical; ends rounded. First abdominal sternum produced into a thick transverse flap. Segmentation distinct on the ventral surface, indistinct dorsally. Spiracles in a J-shaped row. Body hairs 0.05-0.09 mm long. In other respects, similar to mature larva. (Material studied: a few larvae from Panama.)

Weber, 1945, referring to *C. rimosus*: "The larvae appeared to have a scanty, diffuse, whitish mycelial envelope as in *Atta* larvae" (p. 7-8). "The sexual pupae and larvae were covered with whitish mycelial masses" (p. 8). "Larvae of different sizes up to the large, mature worker size as well as several pupae were covered with a network of mycelium" (p. 11).

C. rimosus comalensis Wheeler.—Indistinguishable from *C. rimosus s. str.* (Material studied: a few specimens from Texas.)

Wheeler, 1907, p. 773: "Several of the larvae and pupae that had been injured while the colony was being captured were eaten with avidity not only by the workers but also by the males and winged females."

C. strigatus Mayr.—Plate II, figs. 7-8. Resembles *C. rimosus* except in the following details: No preanal lip. No flap projecting from first abdominal sternum. Body hairs restricted to a few on the sterna of the anterior segments and a few on the pre-anal sterna; length 0.03-0.14 mm. Clypeus and front not spinulose. Head hairs 0.14 mm long. Labrum very small, very broad

and very short; breadth four times the length; distal border slightly convex; lateral borders sinuous, continued distally into a spinule at each corner; posterior surface with a few coarse spinules on the middle third; no spinules on the anterior surface. Mandibles with a typical apical tooth. (Material studied: several specimens from Panama Canal Zone.)

Young Larva. Length 0.67 mm. Resembles young larva of *C. rimosus* except in the following details: Posterior end of body bent ventrally at right angles and forming an acute conoid with the anus on its anterior surface. Segmentation distinct except near the posterior end; intersegmental furrows deeply impressed on the ventral surface. Body hairs 0.03-0.14 mm long. Mandibles with a typical apical tooth. (Material studied: a few specimens from Panama Canal Zone.)

C. olitor Forel.—Apparently similar to *C. strigatus.* (Material studied: a single damaged larva from Panama Canal Zone.)

C. bigibbosus Emery.—"The larvae were swathed in mycelia." (Weber, 1946, p. 123.)

C. bigibbosus faunulus Wheeler.—"Larvae and pupae were covered with mycelium." (Weber, 1946, p. 124.)

C. bigibbosus tumulus Weber.—"Larvae and pupae were covered with the mycelium." (Weber, 1946, p. 127.)

C. (*Mycetophylax*) *brittoni littoralis* Weber.—Weber (1945, p. 25) mentions "a large larva covered with mycelia."

Genus SERICOMYRMEX Mayr

Head on ventral surface near anterior end; ventral profile relatively longer than in most Attini; first spiracle larger than the others. Genal lobes prominent. Head hairs moderately long to very long; few or none above the level of the antennae. Labrum subhemispherical. Mandibles moderately stout; subtriangular in anterior view; base broad and thick; narrowed apically; with the apical portion only slightly curved medially; two apical teeth; spinules moderately numerous. Maxillary palp short, stout, subcylindrical; galea represented by two sensilla.

Wheeler and Bailey (1920, p. 253) state that in this genus the "mouthparts are beautifully adapted for the methods of feeding described by Tanner and Huber. The mandibles are short, stout and acute, and . . . covered with numerous sharp spines, so that the delicate egg-shell or the thin walls of hyphal filaments or of kohlrabi spherules can be held and firmly squeezed and at the same time perforated with many small openings, thus allowing the liquid contents to be rapidly expressed and trickle into the mouth."

S. wheeleri Weber.—Plate II, figs. 9-13. Head on ventral surface near anterior end. Body short, very stout, plump, bean-like; ends large subequal and broadly rounded; dorsal profile very long, C-shaped; ventral profile short and bent ventrally at the posterior third; anus ventral, near posterior end. On either side a short, slender, dark-staining (with acid fuchsin) structure extends from the gena on to the prothorax; its nature and function unknown. Seg-

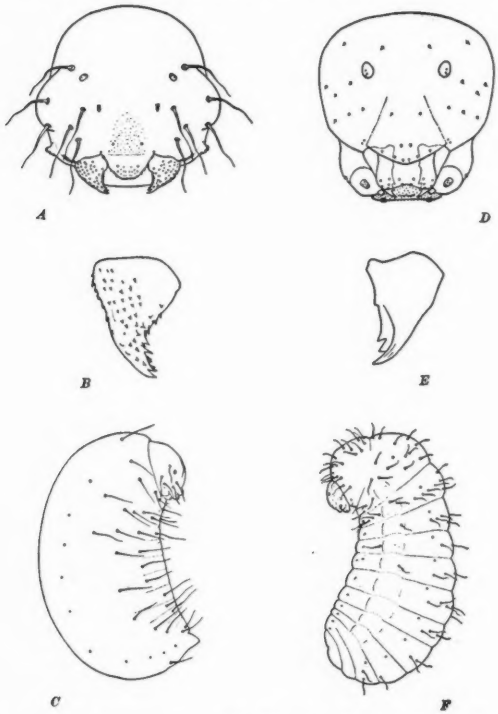
mentation indistinct. Spiracles small; size diminishing progressively from anterior to posterior; arranged in a crescent. Body nearly naked; hairs restricted to ventral surface of thorax and first four abdominal segments and two extremely minute hairs in front of the anus. Body hairs simple, slender, slightly curved, moderately long (0.06-0.14 mm). Head somewhat broader than long; subhexagonal in anterior view, but with all corners rounded; with a median longitudinal welt which widens ventrally. Head hairs 8-12; simple, slightly curved, moderately long (0.1 mm); all below the antennal level. Antennae small, each with three sensilla. Labrum subhemispherical; spinulose; a few sensilla on the anterior surface. Mandibles small, moderately stout, subtriangular in anterior view; base broad and thick; narrow toward the apex, which is slightly curved medially and posteriorly and which terminates in two long slender teeth; moderately spinulose, the spinules coarse and sharp-pointed. Maxillae feebly developed; adnate to the head, except for a small apical lobe; not spinulose but with several minute hairs; palp a short stout peg tipped with a rounded transparent cap; galea represented by two sensilla. Labium subhemispherical, short, scarcely visible from in front; palp represented by a cluster of sensilla on the distal surface. Hypopharynx with spinules in transverse rows. (Material studied: several specimens from British Guiana collected by Dr. N. A. Weber.)

S. amabilis Wheeler.—Text fig. 1, figs. A-C. Head on the ventral surface near the anterior end. Body short, very stout, plump, bean-like; ends large, subequal and broadly rounded; dorsal profile very long and C-shaped; ventral profile much shorter than dorsal but still relatively long and only slightly concave. Anus ventral, near posterior end; postnatal lip conoidal. Segmentation indistinct. Spiracles small, the first larger than the others; arranged in a crescent. Body hairs mostly restricted to the ventral and lateral surfaces, a few dorsal; long (0.2 mm), simple, tapering, flexuous. Integument sparsely and minutely spinulose. Head about as broad as long; occipital border strongly rounded; genal lobes moderately large and prominent; clypeus sparsely and minutely spinulose. Head hairs like body hairs; one pair above the antennal level, five pairs below. Antennae very small; each with three sensilla. Labrum small, subhemispherical, spinulose. Mandibles small, moderately stout, subtriangular in anterior view; base broad and thick; narrow toward the apex which is slightly curved medially and which terminates in two small acute teeth; moderately spinulose, the spinules coarse and sharp-pointed. Maxilla feebly developed; adnate to the head; except for a small apical lobe; palp a short stout subcylindrical peg; galea represented by two sensilla. Labium short, subhemispherical, scarcely visible from in front; palp represented by a cluster of sensilla on the distal surface. (Material studied: several specimens from Panama Canal Zone.)

The differences between *amabilis* and *wheeleri* are much greater than those usually found among congeners. They differ markedly in body shape; in the postanal lip; in the size, shape and arrangement of hairs on the head and body; in the spinules on the integument; and in the shape of the head. In fact, *amabilis* more closely resembles Trachymyrmex than its own congener *wheeleri*.

Wheeler, 1925, p. 158: "The ants placed their eggs, larvae and pupae on the fungus-covered surfaces and in the crypts. . . . Since I never saw the workers administering hyphae or 'kohlrabi' to the larvae, . . . I infer that the latter when hungry merely reach out and crop the fungus. The larvae are short, thickset and beset with sparse, long, flagellum-like hairs. The head is large and subrectangular, bearing small, acute mandibles covered with acute points. This type of mandible, which I find to be peculiar to the Attini, seems to be adapted to puncturing the delicate fungus hyphae and expressing their juices."

Wheeler, 1937: "Some time after the larvae hatch they are carried by the workers to other parts of the garden and placed in contact with fresh masses of the fungus. Since the workers were never observed in the act of administering bromatia to the larvae, it was inferred that the latter merely



Text Figure 1.—*Sericomyrmex amabilis* Wheeler, Figs. A-C.—A, head in anterior view, ×62; B, right mandible in anterior view, ×185; C, larva in side view, ×21. *Megalomyrmex* (*Cepobroticus*) *symmetochus* Wheeler, Figs. D-F.—D, head in anterior view, ×93; E, right mandible in posterior view, ×185; F, larva in side view, ×15.

reach out and crop the food that is within reach of their mandibles" (p. 47). "It is . . . probable that the larvae of the incipient colony [in the higher Attines] eat the mycelium directly and that larval feeding in this very early phase of colony development may really represent an ancient phylogenetic stage which persists throughout the life of the colony in Sericomyrmex and other primitive genera" (pp. 49-50).

When the *amabilis* colony was host to the guest-ant *Megalomyrmex* (*Cepobroticus*) *symmetochus* Wheeler, Wheeler observed (1925, p. 162) that "the guest ants kept their brood in small clusters scattered throughout the garden and each cluster was cared for by a few workers. Although the ants and their brood were thus intermingled, the workers of each species lavished their attention exclusively on their own eggs, larvae and pupae and were never seen even to transport the progeny of the other species from one part of the garden to another."

"The larvae and pupae of the *Cepobroticus* can readily be distinguished from the *Sericomyrmex* brood. The larvae are more slender and more cylindrical and have smaller heads, with flat 3-toothed mandibles. The hairs on the body are more numerous, shorter and stouter, though rapidly tapering at their tips." (Wheeler, 1925, p. 163.)

I have prepared Text fig. 1 from type larvae to show some of the differences between host and guest.

S. harekulli arawakensis Weber.—Weber (1946, p. 142) has observed larvae covered with hyphae.

S. impexus Wheeler.—"Larvae in the nest were naked." (Weber, 1946, p. 142.)

S. urichi Forel.—"Both larvae and pupae are swathed in mycelium but the larvae may at times be partially to completely naked." (Weber, 1945, p. 43.)

Genus TRACHYMYRMEX Forel

Postanal lip conical. Body hairs on entire ventral surface. Genal lobes large and prominent; six hairs on each. Head hairs moderately long; mostly below antennal level, only a few above. Labrum subhemispherical. Mandibles densely spinulose; with apical portion strongly curved medially; one apical tooth. Maxilla with very few spinules; palp represented by a cluster of sensilla; galea by one or two sensilla.

Wheeler and Bailey, 1920, p. 253: "Mouthparts beautifully adapted for the methods of feeding described by Tanner and Huber. The mandibles are short, stout and acute, and . . . covered with numerous sharp spines, so that the delicate egg-shell or the thin walls of hyphal filaments or of kohlrabi spherules can be held and firmly squeezed and at the same time perforated with many small openings, thus allowing the liquid contents to be rapidly expressed and trickle into the mouth."

T. septentrionalis obscurior Wheeler.—Plate II, figs. 14-19. Head on the ventral surface at a considerable distance from the anterior end. Body short, very stout, plump, bean-shaped; slightly compressed; subelliptical in dorsal

view, but slightly constricted at the middle; dorsal profile very long and C-shaped, ventral short and nearly straight; ends large, subequal and broadly rounded. Anus ventral; near posterior end; with a conspicuous posterior lip which is surmounted by a small ventral conical projection. Spiracles small; in a crescentic row. Body mostly naked; hairs few; restricted to the ventral surface; simple, short (0.16 mm) and nearly straight. Head subquadrate in anterior view, but with the occipital angles broadly rounded; genae produced laterally into conspicuous subhemispherical lobes. Head hairs few; mostly below the antennal level; bases moderately stout, attenuated apically; slightly curved; moderately long (0.04-0.14 mm). Antennae small; each with three sensilla. Labrum small, subhemispherical, spinulose. Mandibles moderately large; very stout at the base but attenuating rapidly toward the apex which is strongly curved medially and which bears a long slender acute tooth; densely covered with coarse sharp spinules. Maxillae feebly developed; adnate to the head except for a small free apical lobe; the surface bearing a few spinules, a few sensilla and two minute hairs; palp a low elevation bearing two sensilla; galea a low elevation bearing one or two sensilla. Labium very small; concealed in anterior view; bearing a few minute hairs; palp a low rounded elevation which is densely spinulose and bears a few sensilla. Hypopharynx densely spinulose; spinules in short transverse rows. (Material studied; numerous larvae from Texas.)

Wheeler, 1907. An excellent photograph of the brood (Fig. 21 on p. 751). "The older larvae and young pupae . . . are always free from adhering hyphae, so that their surfaces are always smooth and glistening" (p. 752).

T. jamaicensis Ern. André.—Similar to *T. septentrionalis obscurior*. (Material studied: a single damaged specimen from Culebra Island.)

T. phippsi Weber.—Weber (1946) refers (p. 150) to "larvae with many tufts of hyphae on their integument" and figures (Fig. 3 and 4 on p. 121) an outline of a larva in side view and the mouth parts in side view.

Genus ACROMYRMEX Mayr

Body hairs short and stout; not restricted to ventral surface. Genal lobes large. Head hairs relatively short. Labrum subhemispherical. Mandibles densely spinulose; apical portion strongly curved medially; one apical tooth. Galea represented by a cluster of sensilla.

Bruch (1928, p. 345) describes the hairs as "una especie de ganchitos pardos, duros (quitinosos), formados por una pieza basal y dos ganchitos apicales divergentes en el ápice."

A. octospinosus (Reich).—Plate III, figs. 7-9. Head on the ventral surface at a considerable distance from the anterior end. Body short, very stout, plump, bean-like. Ends large and broadly rounded. Dorsal profile extremely long, C-shaped; ventral profile relatively short, concave. Anus ventral and at a considerable distance from the posterior end; posterior lip prominent. Segmentation indistinct. Body hairs numerous and uniformly distributed; resembling head hairs; extremely short (0.03-0.06 mm), rather stout,

the tips recurved or with two or more fine branches; apparently without alveolus, trichopore and articular membrane. Head a third broader than long; subtrapezoidal in anterior view, but with the occipital angles broadly rounded; genal lobes large but inconspicuous, scarcely protruding beyond the sides of the head. Head hairs short (about 0.05 mm), moderately abundant, uniformly distributed; resembling body hairs, but with alveolus, trichopore and articular membrane; base stout, tapering abruptly to a slender apical portion, the tip minutely bifid or trifid. Antennae small, each with three sensilla. Labrum small, subhemispherical, densely spinulose. Mandibles small, with moderately stout base; the more slender apical portion curved medially and terminating in a slender acute tooth; densely spinulose (except apical tooth), the spinules coarse and sharp. Maxillae reduced; long and narrow and adnate to the head except for a free apical lobe; coarsely spinulose; palp a short, stout, subcylindrical papilla; galea represented by two sensilla on a slight elevation. Labium small; mostly concealed by other mouth parts; spinulose, the spinules arranged in transverse rows; palp represented by two minute sensilla on a slight elevation. Hypopharynx spinulose. (Material studied: three larvae from British Guiana.)

Weber, 1945: "the pupae [in one observation nest] were covered densely with a white mycelium while the larvae were bare and glistening" (p. 65). "The larvae and pupae are commonly swathed in a mycelium" (p. 70).

Wheeler (1937, p. 49) reports that the feeding of the larvae of this species is very similar to that of *Atta cephalotes*. "A larva of *octospinosus* that was resting on its back was seen to receive a pellet of bromatia from a worker, to hold it in its mouth with the mandibles, and to eat it by abrading the surface while occasionally rotating it, without breaking off pieces." A minute larva in an incipient colony "seemed to be feeding on the fungus, as its ventral surface was curved into the mass of hyphae" (p. 50).

A. emilii Forel.—Similar to *A. octospinosus*. (Material studied: two larvae from British Guiana.)

A. lundi Guérin.—Plate III, figs. 1-6. Head on the ventral surface at a considerable distance from the anterior end. Body short, very stout and very plump, bean-shaped; somewhat compressed; narrowed at the middle; both ends large and broadly rounded; dorsal profile extremely long, C-shaped; ventral profile, very short and slightly concave. Anus ventral and at a considerable distance from the posterior end; postanal lip forming a tubercle. Segmentation indistinct. Spiracles small; arranged in a subcrescentic row. Body naked except for about 40 minute (length 0.027 mm) scattered spine-like hairs, which are stout, curved and rather bluntly pointed; none on ventral surface. Integument finely and reticulately rugulose [artifact?]; with minute spinules in short transverse rows on the prosternum. Head about a third broader than long; quadrangular; occipital border nearly straight; the middle of each side produced into a huge suborbicular genal lobe which projects conspicuously from the side of the head; shape of lobe somewhat variable; integument of head granulose [artifact?]. Head hairs few (about a dozen); except for an occipital pair, all are below the antennal level; only one on each genal lobe; head hairs

short (0.05 mm), stout, nearly straight, only slightly attenuated toward the apex which is blunt and spinulose. Antennae small; each with three sensilla. Labrum small, subhemispherical; partially retracted into head; spinulose distally. Mandibles moderately large, short and stout; distal portion attenuated somewhat and curved medially and backward to terminate in a slender, acute apical tooth; surfaces mostly covered with coarse sharp spinules. Maxillae elongate, narrow; mostly concealed behind mandibles; adnate to the head, except for a free apical lobe; basal half spinulose; palp a short, stout, subcylindrical peg; galea represented by two minute sensilla. Labium very short and very broad; concealed behind the other mouth parts; consisting mostly of two coarsely spinulose lobes separated by a deep impression; each palp represented by two adjacent sensilla. Hypopharynx spinulose. (Material studied: three larvae from Argentina.)

Bruch (1919): Colony-founding queens feed their eggs to larvae (*fide* Wheeler, 1933, p. 9).

A. coronatus globoculis Forel.—"Some of the larvae and pupae were free of the mycelium in this nest while others had a little. Ordinarily larvae and pupae are well swathed in mycelium." (Weber, 1946, p. 152.)

Genus PSEUDOATTA Gallardo

I have seen no larvae of this genus, but according to Bruch's description and photograph of two larvae in profile (1928, Pl. I, fig. 1) the body has the typical attine shape. The hairs on the head and body are flexuous and slightly curved; those on the dorsal surface are bifurcate at the tip; the hairs on the ventral surface of the thorax are much more abundant.

Bruch, 1928, p. 345: "Las larvas . . . son del tipo común de las larvas de podadoras del género *Acromyrmex*. Solamente su forma es algo más cilíndrica, poco menos estrechada hacia las extremidades y apenas menos encorvada. Sobre la cabeza y el cuerpo se destacan algunas setas parduscas, semiblandas y algo encorvadas, solamente alguna de éstas (sobre el dorso) son bifurcadas en el ápice; en la parte ventral del antecuerpo (tórax), estas setas son mucho más abundantes."

Wheeler, 1937, p. 54: "Pseudoatta is, as we should expect it to be, most closely related to its host genus, Acromyrmex. . . . The larvae of Pseudoatta, moreover, are described by Bruch as resembling those of Acromyrmex."

Genus ATTA Fabricius

Postanal lip subtriangular and flap-like. Body hairs mostly restricted to first four body segments and vicinity of anus. Posternum spinulose. Genal lobes small and inconspicuous. Head hairs numerous, uniformly distributed, relatively short. Labrum subhemispherical. Mandibles densely spinulose; apical portion strongly curved medially, one apical tooth. Maxilla with few spinules; palp represented by one sensillum, galea by a cluster of sensilla.

Forel, 1923, pp. 89-90: "Madame *Atta* alimente *directement* ses larves avec les oeufs qu'elle pond (adelphophagie directe). Elle chatouille la larva avec ses antennes, jusqu'à ce que celle-ci ouvre ses mandibules. Alors la ♀

pousse l'oeuf fraîchement pondu qu'elle saisit contre les mandibules de la larve, sur le ventre de cette dernière, et la larve le mange. Si la larve est petite et jeune, la ♀ donne ensuite le reste de l'oeuf à une seconde larve. Mais, si la larve est grande, elle déguste l'oeuf tout entier en trois à cinq minutes. [Huber] a observé ainsi 4 oeufs pondus administrés en deux heures à des larves, une fois même 8 dans le même laps de temps. Jamais H. n'a vu des ♀ donner à leur larves les choux-raves de leur jardin, ni les manger elles-mêmes. . . . Elle peut même élever sa couvée sans avoir de j. de ch., ce que [Möller] put observer une fois dans un nid artificiel jusqu'a l'éclosion des ☿. Dès que les premières petites ☿ de 2 à 3 mill. de long. sont écloses, la scène commence à changer, et les ☿ se chargent de soigner les nymphes. Elles continuent aussi pendant un certain temps à alimenter les larves et leur mère elle-même avec des oeufs pondus par cette mère commune."

Forel, 1928, Vol. II, p. 270: "But over and above this Huber managed to see how Madame *Atta* feeds her larvae *directly* with the eggs she lays (direct adelphophagy). She strokes a larva with her antennae until it opens its mandibles; she then seizes a new-laid egg and thrusts it against the larva's mandibles, and on to its gaster, whereupon it is eaten. If the larva is young and small, the ♀ then gives the rest of the egg to a second larva, but if it is large it consumes the whole egg in three to five minutes. Huber saw four eggs administered to various larvae in two hours, and on one occasion even eight in the same space of time. He never saw the ♀ eat kohlrabi clusters from their gardens or give them to their larvae. . . . She can also rear her brood without fungus, as Möller once managed to observe while watching an artificial nest till the workers were hatched. With the appearance of the first small ☿ (2-3 mm. long), the scene begins to change; the ☿ take charge of the nymphs, and for a certain length of time they also continue to feed the larvae and their common mother herself with the eggs she lays."

Weber, 1945, p. 7.—The larvae "have a scanty, diffuse, whitish mycelial envelope."

Hagen (1939, p. 32) states that staphylinid beetles "plunder the live young larvae of the nest."

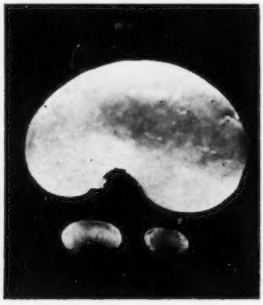
According to Wheeler (1910, p. 332-333) the colony-founding queen feeds her first larvae with her own eggs, thrusting them directly into their mouths. After the first workers emerge they continue to feed larvae with their mother's eggs. When the fungus-garden has begun to thrive larvae are fed "kohlrabi" by the workers.

Wheeler and Bailey (1920, p. 253) state that "the mouth parts are beautifully adapted for the methods of feeding described by Tanner and Huber. The mandibles are short, stout and acute, and . . . covered with numerous sharp spines, so that the delicate egg-shell or the thin walls of hyphal filaments or of kohlrabi spherules can be held and firmly squeezed and at the same time perforated with many small openings, thus allowing the liquid contents to be rapidly expressed and trickle into the mouth."

A. cephalotes (Linnaeus).—Plate III, figs. 10-16. Head on the ventral

surface at a considerable distance from the anterior end. Body short, very stout and plump, bean-shaped; slightly compressed; outline when viewed from above or below subelliptical but slightly narrowed at the middle; depth greatest at the middle, decreasing slightly and equally toward the ends; both ends large, subequal and broadly rounded. Dorsal profile extremely long, subcrescentic; ventral profile short, slightly concave. Anus ventral and at a considerable distance from the posterior end; with a conspicuous posterior lip. Segmentation indistinct. Spiracles small; in a subcrescentic row. Body nearly naked, having only a few minute (0.05 mm long) simple, slender, tapering hairs, which are largely restricted to the ventral surface of the thorax and the vicinity of the anus. Integument of prosternum with minute spinules. Head somewhat broader than long; suboctagonal in anterior view; a feebly developed genal lobe on each side near the middle; integument of gula spinulose. Head hairs moderately long (0.09 mm), moderately abundant, uniformly distributed, slender, tapering, slightly curved or flexuous. Antennae small; each with three sensilla. Labrum small subhemispherical, spinulose; mandibles small, short and stout; apical portion abruptly attenuated and curved medially; surfaces coarsely and densely beset with sharp spinules; with an elongate acute apical tooth. Maxillae reduced; long and narrow; adnate to the head; sparsely spinulose; palp a small short subcylindrical papilla; galea represented by a pair of small short subconical papillae. Labium reduced; mostly concealed; very short and very broad; produced at each corner into a low rounded elevation, which bears a cluster of minute hairs, a few spinules and a single minute discoidal sensillum (= palp). Hypopharynx spinulose. (Material studied: several larvae from British Guiana.)

Sexual larva. Text fig. 2. I have examined three larvae of *cephalotes*, presumably queens and probably fully grown, collected by Dr. N. A. Weber in Trinidad. The largest is 16 mm long, and really enormous; extremely plump, looking as if it were about to burst; more curved ventrally than smaller larvae and hence with the head nearer the anus; no posterior anal lip; head relatively minute; gula inflated into two lobes, which are spinulose.



Text Figure 2.—*Atta cephalotes* (Linnaeus). Sexual larva and two mature worker larvae, ×2.

Tanner (1892, pp. 124-125; quoted by Wheeler, 1907, pp. 682-683; by Wheeler and Bailey, 1920, p. 252; and by Wheeler, 1937, p. 47) described the newly hatched larvae of *cephalotes* as exceedingly minute helpless grubs, both legless and blind. They "are usually placed on top of the nest and are constantly attended by the smallest workers — the nurses — who separate them into divisions according to size. At first it seemed a mystery, how these minute grubs could be fed so systematically, knowing that each individual larva was only one among so many, yet certain it was, that all were equally attended to. Further observations showed that nature had provided most efficiently for them to ask for food when they required it. This the larvae do by pouting their lips; at this notification of their requirement the first nurse who happens to be passing stops and feeds them. The nurses are continually moving about among them with pieces of fungus in their mouths ready for a call for food. The nurses feed the minute larvae by merely brushing the fungus across their lips showing that the spores alone are sufficient for its food at that period of its life. But it is not so when the larvae have increased so much in size, that the pout can be seen without a glass, for then the whole piece after having been manipulated by the nurse's mandibles into a ball, in the same manner as the leaves are served, when they are first brought into the nest, is placed in its throat and if that is not sufficient the pout continues when the next one and even the next passing proceeds with the feeding, till the pout is withdrawn, showing that it is satisfied. No further notice is then taken of it by the feeders, until it again asks for a meal by pouting later on in the day."

Weber (1945): "A larva on its back was watched feeding on a bromatium. The workers in such cases rotate such a mass between their mandibles, then place it on the mouthparts of the pouting larvae. A larva was lying askew on its back feeding. It had a bromatium between its mandibles which went in and out with a somewhat piston-like motion and laterally, the labium being coördinated with these motions. Eating, as in the adults, seemed to be a process of attrition and lapping up of expressed juices. The larva handled the mass easily. Another larva had such a mass on one side of the mouth, the mouthparts working in and out without affecting the bromatium, when a media worker came up and regurgitated to it, working its own hypopharynx and palpi to the corner of the mouth opposite to that of the bromatium. It acted thus for 15-30 seconds when it passed on. The larva worked its mandibles for a moment later, then became quiet" (p. 76). "By April 30 the ants had moved nearly all of the brood (consisting of tiny pupae, larvae and eggs) to the bottom of the nest under the garden except one large pupa, one large larva and one much smaller larva. The garden continued to flourish. The situation was on May 1 as above when the ants were moved to a new nest. The next day the garden appeared much as before with the queen on top towards the center and the large larva and pupa in separate open cells attended by many ants. It was clear for some days that [the] large larva and pupa had been getting much more attention than the remainder of the brood, either from more workers or from workers more times" (p. 77). "A part of one fungus garden of a large, mature colony was collected April 17

and placed in an observation nest. With the garden were huge sexual larvae. . . . By April 20 the ants had removed much exhausted substrate and several sexual larvae which had shrivelled as a result of the ants lapping the cut and damaged integument. One intact sexual larva remained. The others had been too thoroughly defended when the nest was opened and had been cut by the mandibles of the workers. . . . The larva pupated May 1 or 2 (pp. 78-79). "The larvae and pupae are often swathed in mycelium" (p. 84).

Weber (1946, p. 164): "Then the ant walked over to a shining larva which was longer and bulkier than the nursemaid. The mouthparts of the larva were somewhat extruded. The ant placed the bromatium on these mouthparts, the larva lying on its back, and the larva commenced to feed. The mouthparts went in and out with a piston-like motion. Within two or three minutes the bromatium had been eaten but the larva maintained the working of its mouthparts. . . . Eggs, larvae and pupae were all clean and shining . . . and all free from mycelia."

According to Wheeler (1907, pp. 681-682), Tanner was the first to study Attini "in artificial nests and to prove that not only the adult ants but also the larvae feed on the fungus hyphae. . . . 'It is the fungus they eat, and with small portions of it the workers feed the larvae.' "

Wheeler (1937, pp. 48-49): "The eggs, larvae, and pupae of *cephalotes*, roughly classified by the workers according to size, are kept in the most flourishing portion of the gardens. Tanner's statement concerning the feeding of the young larvae with spores is incorrect, of course, because these fruiting bodies are not produced by the fungus. He also failed to notice that the workers also often feed one another and their larvae with regurgitated food. The workers roll masses of bromatia between their mandibles before placing them in the mouths of the pouting larvae. Dr. Weber noticed that one larva, which was lying on its back, on receiving the pellet of bromatia, worked its mandibles in and out with a piston-like movement while at the same time moving its labrum up and down. Eating, as in the adult, is a process of attrition and a lapping up of the juices exuding from the crushed bromatia. On another occasion, a worker minima was seen to be rotating a mass of bromatia between its mandibles and fore tarsi. It then walked over to a plump larva whose mouthparts were extruded ('pouting'), as it rested on its back, and placed the pellet over its mouth. The larva ate with the piston-like movement of its mandibles and after consuming the pellet within two or three minutes, worked its mouthparts a moment longer before becoming quiet. A third larva had at the side of its mouth a mass of food which it seemed to be unable to masticate, though it worked its mandibles and labrum. A worker media came up and regurgitated to it assiduously, directing its tongue and palpi to the corner of the larva's mouth opposite to the bromatial pellet. The regurgitation continued for thirty seconds, after which the worker passed on. In another *cephalotes* colony the workers for several days kept a worker and a soldier larva, which were much larger than the remainder of the brood, in the same or in separate cells of the garden and gave them special care. They unquestionably received more attention than the small larvae, either

from more workers or from more frequent feeding by the same workers. The more conspicuous 'pouting' of these larger larvae, which is perhaps accompanied, as it is in the larvae of the social wasps, by the emission of some trophallactic secretion, probably tends to attract more of the passing workers and may thus account for the more frequent feeding. . . . On April 17, 1935, Dr. Weber installed in an observation nest a portion of a large *cephalotes* colony that was rearing its huge sexual larvae. The workers had defended these larvae too well when the nest was exposed, swarming over them and holding on to the larvae with their mandibles, so that the integument of nearly all was cut in many places. By April 21 only one was left, the rest shriveling up as the result of the workers' lapping up their juices through the cuts in their integument. This larva was fed with bromatia in the same manner as the worker larvae and similarly rested on its back."

A. columbica Guérin.—Text fig. 3. Similar to *A. cephalotes*. (Material studied: several larvae from Panama Canal Zone.)

Text Figure 3.—*Atta columbica* Guérin. Sexual larva and mature worker larva, ×2.

A. insularis texana (Buckley).—Similar to *A. cephalotes*. (Material studied: several damaged larvae from Texas.)

A. sexdens (Linnaeus).—Similar to *A. cephalotes*. (Material studied: several specimens collected by Dr. N. A. Weber in Venezuela.)

Huber, 1905 (translation 1907): "Somewhere about fourteen to sixteen days after the female *Atta* has established her subterranean dwelling, the first larvae can be clearly seen lying among the eggs which by this time amount to over 100. The fungus garden is now from 1 to 1.5 cm in diameter. The number of larvae increases daily and their rapid growth is especially striking, some attaining within a week a length of fully 2 mm. A month or so after the beginning of the imprisonment the first pupae are to be seen" (p. 358). "Eggs and larvae require to be diligently licked, placed in clusters, or spread out separately, put in contact with the fungus or separated from it and later on laid in the hollow center of the fungus garden, or certain individuals of the brood removed from it" (p. 360). "We therefore find a proportion of 9 eggs devoured to every 10 laid. The foregoing especially unfavorable proportion is doubtless to be attributed to the fact that the larvae required from the

beginning to be fed with the eggs. . . . When the egg has been laid, the mother ant tests it for some seconds by a process of tasting, and then turns to one of the larvae, which she caresses with her antennae until it begins to move its mandibles. The egg is then thrust between its mouth parts with considerable force. These continue to work back and forth upon the egg, which either stands perpendicular to the larva, or, as is more frequent, lies along its ventral side. In the latter case the mother-ant often presses the egg with her foot against the larva. If it is still very young, the egg is generally after a time taken away and given to another larva. A good-sized larva is, however, capable of devouring an egg in from three to five minutes, so that nothing but the leathery skin remains, which is later removed by the mother-ant. At any rate, I have clearly observed that a larva whose mouthparts were in vigorous action upon an empty egg-skin had this residue licked away by the mother-insect, and that then the movement of the larva ceased. It is no doubt due to the rapidity with which the larvae devour the eggs that one so very rarely comes upon them in the actual process of eating them, but I have clearly established the fact that feeding of larvae with eggs is a very frequent occurrence. Thus, for example, I have noted in a forenoon the process of egg laying to take place four times and the feeding of larvae with eggs an equal number, and in the afternoon during two hours eight cases of egg-laying and four of feeding these to the larvae. I am of the opinion that up to the time of the appearance of the workers eggs form the exclusive food of both the mother-ant and her brood. I have never detected a case of the *Atta* female supplying the larvae with either the mycelial threads or the kohlrabi of the fungus (*Rosites*). . . . In regard to the feeding of the brood by a solitary maternal ant, Janet and Forel, as I understand it, have advanced the opinion that the larvae are fed with a nutritive liquid derived from the eggs devoured by her and which she secretes in the communal stomach (jobot). In respect to *Atta*, at least, this is not the case. The eggs are here directly fed to the larvae. Comparative investigations must determine whether or not this method of feeding takes place with other ants. It is at least noteworthy that in the case of *Atta* the larvae are not later on fed by the workers with their stomach contents, but directly with the kohlrabi growth of the fungus" (pp. 361-363). "The larvae, the number of which rapidly increases, are still fed with eggs [after the first workers emerge]. It is of interest to observe how in this task the workers gradually relieve the mother-ant of the larger share. It often happens that the mother-ant places an egg in the regular way against the mandibles of the larva, but it is frequently seen that it is not satisfactorily arranged or is simply deposited in the nest; in the latter case the workers pick it up and give it to the larva. The workers also stroke the larvae with their antennae in the same manner as the mother-ant, so as to cause them to move their mandibles when the egg is given to them. I have generally been able to observe the same egg being given to several larvae by the workers, who slowly squeeze it with their mouthparts" (pp. 363-364). "In consequence of this steady enlargement of the fungus garden the larvae (and the eggs as well) are gradually removed from the domain of the mother-ant. It is not surprising that at first the larvae continue to be fed with eggs, since at this

period the quantity of kohlrabi is small, being barely sufficient for the adult workers. Nevertheless, I once noticed a small worker offering a half-eaten kohlrabi to a larva, and finally mashing it up in a very practical way in front of its mouth. In this way a beginning is doubtless made in the further feeding of the larvae with kohlrabi, which comes to be the general thing as soon as the necessary supply is obtainable" (p. 366).

"*Summary.*— . . . The larvae are at first fed with eggs by the mother ant, and during the transitional period by the young workers" (p. 367).

Huber, 1905 (translation 1907): Photographs of numerous larvae in fungus gardens (Pl. II, fig. 12 and Pl. IV, fig. 22); the feeding of a larva (Pl. IV, fig. 20).

Weber (1946): "Larvae and pupae were naked and glistening" (p. 167). "Smooth and glistening larvae and pupae" (p. 168). "A minima worker was seen to give a bromatium to a larva lying obliquely on its dorsal surface, *i.e.*, turned partly on one side. The larva grasped it readily with the mouthparts" (p. 168).

Wheeler, 1907, pp. 698-699: "As soon as the larvae appear they are fed directly with eggs thrust into their mouths by their mother. Huber concludes that this is their normal diet till the first workers hatch. . . . [Then these] feed the larvae with their mothers' eggs. . . . [Later] the 'kohlrabi' has become so abundant that it can be fed to the larvae."

Wheeler and Bailey (1920, p. 252) give in translation a part of the passages from Huber (pp. 361-362) that I have quoted above.

Wheeler (1928, p. 203 and 1933, p. 9): Colony-founding queens feed their eggs to larvae.

Wheeler, 1937, p. 49: "Larval feeding in an *A. sexdens* colony kept under observation in British Guiana was found to be precisely the same as in *cephalotes*."

A. sexdens rubropilosa Forel.—Autori (1942) gives the life cycle as follows: egg 22 days, larva 22 days, pupa 10 days.

A. sexdens vollenweideri Forel.—Bruch (1917) has published photographs of queen larvae (Fig. 3 on p. 160 and Pl. I, c).

DISCUSSION

The larvae of the tribe Attini constitute a well defined and homogenous group which is sharply distinguished from typical myrmicine larvae (such as *Megalomyrmex*, illustrated in Text fig. 1) by the position of the head and of the anus; the shape of the body; the indistinct segmentation; the arrangement of the spiracles; the scarcity of hairs and their restricted distribution; the genal lobes; the reduced mouth parts; the spinules on the mandibles; and the reduced number of mandibular teeth. None of these characters is alone distinctive, but as a group they define the Attini very well.

The larvae of the tribe may be separated into two groups: (1) *Myrmicocrypta* and *Apterostigma*. These agree in having the maxillae and labium fully exposed; the mandibles not curved; and the absence of genal lobes. (2) *Cyphomyrmex, Sericomyrmex, Trachymyrmex, Acromyrmex* and *Atta*. These have the maxillae and labium mostly concealed; the apical portion of the mandibles curved medially; and genal lobes. This grouping confirms in general Emery's opinions on adult taxonomy (as expressed in the *Genera Insectorum*): *Cyphomyrmex, Trachymyrmex, Acromyrmex* and *Atta* represent the main stem of the Attini; *Mycocepurus, Myrmicocrypta* and *Apterostigma* are another line, perhaps more primitive; *Sericomyrmex* is an aberrant genus. The last item is not confirmed in larval taxonomy, for *Sericomyrmex* resembles closely the genera of my second group; it does, however, differ from all other attine larvae in having two apical teeth on the mandibles. Wheeler (1910, p. 320) thought adult *Apterostigma* "very aberrant, resembling in form certain Myrmicines of the subgenera *Aphaenogaster* and *Ischnomyrmex*." The larva of *Apterostigma* is certainly aberrant in the extreme reduction of the mouth parts and in the lack (or extreme scarcity) of spinules on the mandibles, but it does not even remotely resemble the typically myrmicine larvae of Aphaenogaster and Ischnomyrmex.

Within the groups (referred to in the preceding paragraph) larval taxonomy does not correlate closely with adult taxonomy. Genera, to be sure, are easily differentiated, but some congeneric species show differences of generic magnitude,[1] while others differ only in trival characters[2] or not at all.[3]

REFERENCES*

AUTORI, M. 1942—Contribução para o conhecimento da sáuva. (Atta spp.—Hymenoptera-Formicidae). II. O saúveiro inicial (Atta sexdens rubropilosa Forel, 1908). Arq. Inst. Biol. (São Paulo) 13: 67-86, 11 pls., 1 text fig. [*Fide* Biol. Abstr. 17: 2479, 1943.]

BISCHOFF, H. 1927—Biologie der Hymenopteren: eine Naturgeschichte der Hautflüger. (Biologische Studienbücher herausgegeben von Walter Schoenichen, V.) viii + 598 pp., 244 figs. Berlin: Julius Springer.

BRUCH, CARLOS 1917—Costumbres y nidos de hormigas. Anales de la Sociedad Científica Argentina 84: 154-168, 4 pls., 8 text figs.

———1919—Nidos y costumbras de hormigas. Revist. Soc. Argent. Cienc. Nat. 4: 579-581, 2 figs. [*Fide* Wheeler, 1933.]

———1928—Estudios mirmecologicos. Anal. Mus. Nacion. Hist. Nat. "Bernardino Rivadavia" (Buenos Aires) 34: 341-360, 6 pls., 6 text figs.

1 *Sericomyrmyrmex amabilis* versus *S. wheeleri; Acromyrmyrmex lundi* versus *A. octospinosus.*

2 *Apterostigma collare angulatum* versus *A. tramitis; Cyphomyrmex rimosus* versus *C. strigatus.*

3 *Myrmicocrypta urichi* and *M. spinosa; Apterostigma collare angulatum* and *mayri; Cyphomyrmex strigatus* and *olitor; Trachymyrmex septentrionalis obscurior* and *jamaicensis; Atta cephalotes, colombica, insularis texana* and *sexdens.*

* Bibliography of the larvae of the Attini.

FOREL, A. 1922—Le monde social des fourmis du globe comparé à celui de l'homme. Tome 3, vii + 227 pp., 8 pls., 2 col. pls., 28 text figs. Genève: Librairie Kundig.

———1923—Le monde social des fourmis du globe comparé à celui de l'homme. Tome 5, vi + 174 pp., 1 pl., 2 col. pls., 30 text figs. Genève: Librairie Kundig.

———1928—The social world of ants compared with that of men. Translated by C. K. Ogden. 2 vols., 551 + 445 pp., 24 pls. (8 col.), 138 text figs. London + New York: G. P. Putnam's Sons, Ltd.

HAGEN, V. WOLFGANG VON 1939—The ant that carries a parasol. Natural History 43: 27-32, illus.

HUBER, J. 1905—Ueber die Koloniengründung bei Atta sexdens. Biol. Centralbl. 25: 606-619, 625-635, 26 figs. (Translation in Smithsonian Report for 1906: 355-367, pls. 1-5, 1907.)

TANNER, J. E. 1892—Oecodoma cephalotes. Second paper. Trinidad Field Naturalists' Club 1: 123-127.

WEBER, N. A. 1945—The biology of the fungus-growing ants, Part VIII. The Trinidad, B. W. I., species. Rev. de Entomologia 16: 1-88, 8 pls., 1 text fig.

———1946—The biology of the fungus-growing ants. Part IX. The British Guiana Species. Ibid., 17: 114-172, 8 pls., 5 text figs.

WHEELER, W. M. 1907—The fungus-growing ants of North America. Bull. Am. Mus. Hist., 23: 669-807, 5 pls., 31 text figs.

———1910—Ants, their structure, development and behavior. xxv + 663 pp., 286 figs. New York: Columbia University Press.

———1925—A new guest ant and other new Formicidae from Barro Colorado Island, Panama. Biol. Bull., 49: 150-181, 8 figs.

———1928—The social insects—their origin and evolution. xviii + 378 pp., 79 figs. New York: Harcourt, Brace and Co.

———1933—Colony-founding among ants. x + 179 pp., 29 figs. Cambridge: Harvard University Press.

———1937—Mosaics and other anomalies among ants. 95 pp., 18 figs. Cambridge: Harvard Univ. Press.

——— AND I. W. BAILEY 1920—The feeding habits of the Pseudomyrminae and other ants. Trans. Amer. Phil. Soc. (Art. 4): 235-279, 5 pls., 6 text figs.

EXPLANATION OF PLATES

PLATE I.—*Myrmicocrypta urichi* Weber, Figs. 1-8.—1, head in anterior view, ×78; 2, mature larva (1.7 mm) in side view, ×25; 3, very young larva (0.7 mm) in side view, ×25; 4, body hair, ×427; 5, labrum in posterior view, ×427; 6, right maxilla in anterior view, ×427; 7, right mandible in anterior view, ×427; 8, labium in anterior view, ×427.

Apterostigma collare angulatum Weber, Figs. 9-17.—9, head in anterior view, ×50; 10, mature larva in ventral view, ×17; 11, mature larva in side view, ×17; 12, young larva in side view, ×26; 13, labium in anterior view, ×123; 14, left maxilla in anterior view, ×123; 15, body hair, ×77; 16, labrum in posterior view, ×123; 17, left mandible in anterior view, × 307.

Apterostigma tramitis Weber, Fig. 18, left mandible in anterior view, ×297.

PLATE II.—*Cyphomyrmex rimosus* Spinola, Figs. 1-6.—1, head in anterior view, ×100; 2, mature larva in side view, ×27; 3, young larva in side view, ×53; 4, right maxilla in anterior view, ×185; 5, body hair, ×185; 6, right mandible in anterior view, ×267.

Cyphomyrmex strigatus Mayr, Figs. 7 and 8.—7, right mandible in anterior view, ×413; 8, young larva in side view, ×47.

Sericomyrmex wheeleri Weber, Figs. 9-13.—9, head in anterior view, ×60; 10, larva in side view, ×29; 11, right mandible in anterior view, ×185; 12, left maxilla in anterior view, ×103; 13, body hair ×185.

Trachymyrmex septentrionalis obscurior Wheeler, Figs. 14-19.—14, head in anterior view, ×55; 15, larva in side view, ×13; 16, larva in ventral view, ×13; 17, right maxilla in anterior view, ×96; 18, body hair, ×92; 19, left mandible in anterior view, ×92.

PLATE III.—*Acromyrmex lundi* Guérin, Figs. 1-6.—1, head in anterior view, ×56; 2, larva in side view, ×7; 3, larva in ventral view, ×7; 4, head hairs, ×183; 5, body hair, ×183; 6, mandible in anterior view, ×92.

Acromyrmex octospinosus (Reich), Figs. 7-9.—7, head in anterior view, ×58; 8, mandible in anterior view, ×92; 9, five body hairs, ×183.

Atta cephalotes (Linnaeus), Figs. 10-16.—10, head in anterior view, ×45; 11, larva in side view, ×10; 12, larva in ventral view, ×10; 13, left maxilla in anterior view, ×78; 14, body hair, ×78; 15, mandible in anterior view, ×107; 16, spinules on hypopharynx, ×78.

PLATE I

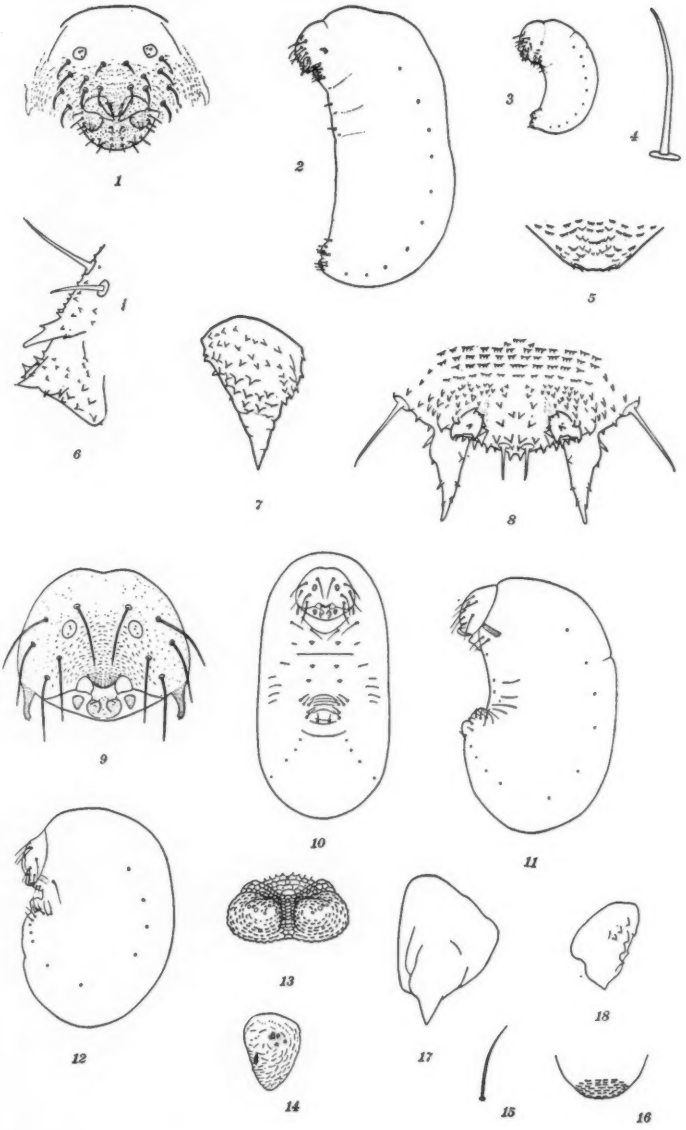


PLATE II

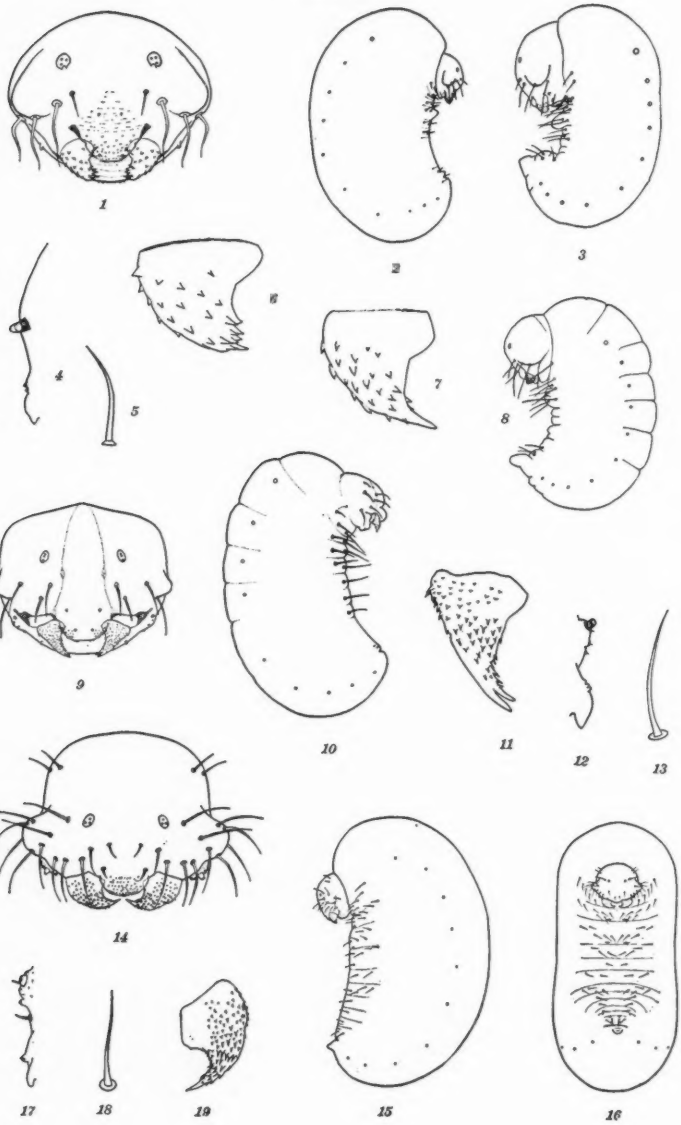
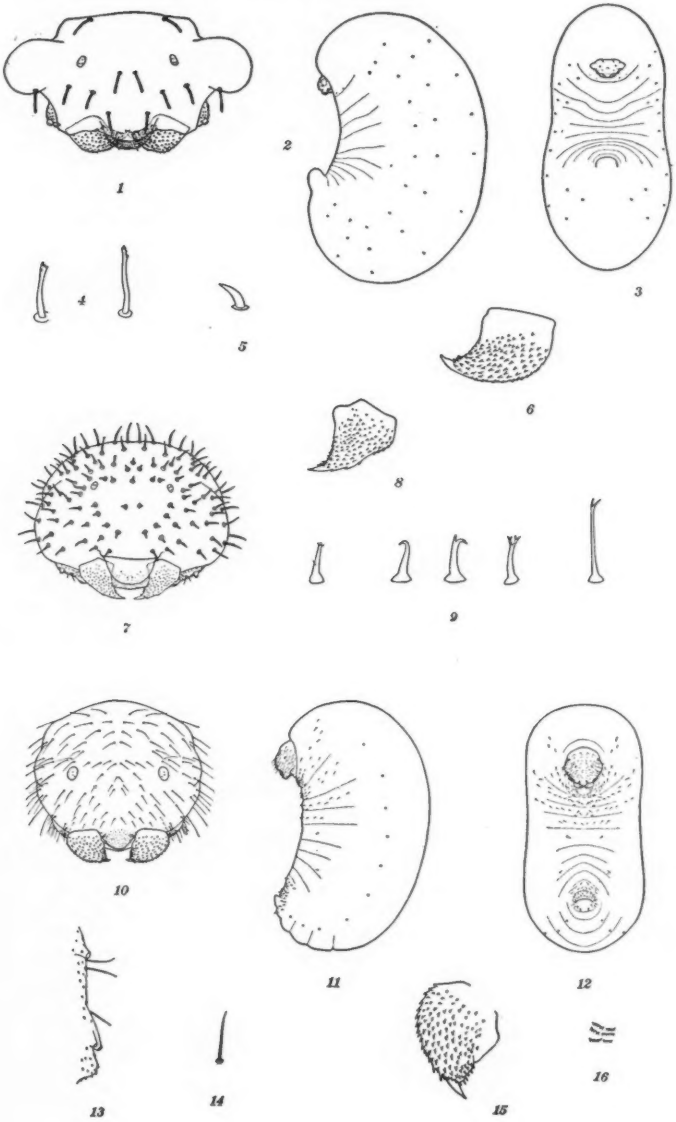


PLATE III



Life History of Elliptio complanatus (Dillwyn, 1817)*

Max R. Matteson

Department of Zoology and Physiology, University of Illinois, Urbana

Introduction

Although *Elliptio complanatus* is a very common fresh-water mussel, found generally through the northern Atlantic seaboard states, comparatively little information can be discovered in conchological literature on its life history or ecology. The reasons for this scarcity of substantial research on the mussel are its doubtful commercial value and the scarcity of investigators in the field. This mussel is not commercially valuable at present, but knowledge derived from a study of its life conditions may apply to other mussels which are economically important.

Investigation described in this dissertation was begun in the summer of 1941. In order to gain sufficient data for completing the study of the life cycle of *Elliptio complanatus*, this research was continued through the summer of 1946. As is often the case in solving a natural life cycle, the intensity of research was not dependent on the manipulator but on the development of the organism itself. Because of the ample facilities of the University of Michigan Biological Station, all of the basic phases of the life history of the mussel studied were investigated at the original site of experimentation.

The primary and almost sole objective, originally, was a study of the life cycle of *Elliptio complanatus*. However, little time had elapsed after initiation of the project before many interesting ecological problems had arisen. Those problems which are not directly associated with the life cycle will be discussed in a later paper.

Apparatus and Methods

As a knowledge of certain physico-chemical features was essential for pursuance of the problems involved, certain determinations were made on all bodies of water connected with the research.

It might seem that a very exhaustive system of determinations would portray a more accurate impression of the problem at hand. However, some factors deemed necessary for a complete analysis of fresh water were judged to be superfluous in the study of the life-cycle. As a result, only certain significant physico-chemical conditions were determined.

The most important environmental factors tested were water temperatures, hydrogen ion concentration, free carbon dioxide, dissolved oxygen, dissolved carbonates and bicarbonates, and conductivity. In all cases the tests followed

* Contribution from the Department of Zoology and the Biological Station, University of Michigan

as closely as possible those delineated in *Standard Methods for the Analysis of Water and Sewage*.

Apparatus used for the collection of mussels for various purposes was, almost entirely, prepared from materials at hand. Those clams obtained from the lake used as the source of supply were secured during the summer months and could be easily gathered by hand. On windy days, they were collected with the aid of a glass-bottomed bucket. Because particles of clay, of which the lake bottom is largely composed, tended to obscure visibility the bucket was often discarded and the clams obtained merely by sense of touch.

During those months when the water was cold, hand-picking was impossible. Mussels obtained during fall and spring were secured by raking them from deeper water by means of a rake equipped with a screen apron. This method proved to be very laborious and slow but seemed to be the only solution. Coker (1919) suggests several methods for the collection of mussels, including the use of a modified rake.

For winter use, mussels were placed in concentrated groups in shallow water in the fall. Stakes were driven firmly into the bottom among the clam concentrations. After the ice had formed, the stakes remained as markers for locating the supply. When a supply was needed, a hole was cut in the ice and the clams were easily extracted from the bottom. This procedure was highly satisfactory. The clams were sluggish to the extent of being almost dormant during the winter, most of them moving little except to imbed in the bottom. Some remained until gathered in the same position which they had taken when dropped in the fall, entirely on the surface of the bottom.

Individual identification of the mussels was assured by first cleaning the shell and then filing the desired symbol on it by use of a three-cornered file. Several methods used by other workers in the field were considered but none seemed practical for marking the large numbers of clams used for studying yearly growth rate. Up to the present, erosion of the valves, even under the most adverse conditions, has been insufficient to destroy the identification marks or even seriously to affect their legibility.

Measurements of growth were taken for length, height, width and weight. Length, height and width were obtained by a simple instrument constructed from two pieces of maple flooring (Fig. 1). Maple was purposely selected because of several desirable inherent qualities. A portion of one piece was fitted into the other and permanently attached thereto. The remainder of the second piece was allowed to slide against the fixed portion thus making a simple caliper. An accurate rule, graduated to millimeters was attached to the fixed portion. Weight was obtained by means of a torsion balance equipped with a home-made carrier so that it could be taken into the field. The sides of the carrier acted as windbreaks when used on the lake-shore.

At various times it was necessary to store clams for future study. This was necessarily accomplished in anticipation of two types of investigation: (1) That for clams needed in the living state and (2) that for those studied after killing and preserving. The method for storage of living clams for winter study has already been discussed.

Clams needed for study during subsequent summer months were stored in large earthenware tubs in an aquarium shelter. Originally it was thought that a small constant flow of surface lake water would be desirable for the clams' well-being. However, due to the increased water temperature, lack of proper food, and perhaps other factors, mortality among the stored clams was high. It was found that the clams fared much better by having the water unchanged. This was due to the fact that water stored in suitable containers and protected from the sun during the day will experience a considerable drop in temperature during cool nights but will not regain as high a temperature during the following day, as does the surface water of a lake. The resulting cooler average temperature lowers the metabolic rate of the clams and, therefore, their oxygen consumption.

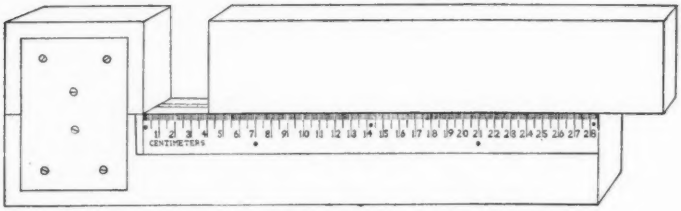


Fig. 1.—Caliper used for measuring clams. The smallest unit on the scale is one millimeter; the entire range is 285 millimeters.

Clams remaining on the site employed for winter storage were also used during the summer. However, on the advent of warmer water-temperatures, the clams tended to move from the shoal, where they had been placed, into deeper water and were thus too scattered and difficult to obtain for practical purposes, other than for incidental experimentation.

Cages, four feet square and covered with one-half inch mesh screen, were employed to a certain extent for storing live mussels but were quite unsatisfactory due to the effects of wave action.

As a complete history of summer development, particularly for gametogenesis, was desirable. clams in sufficient quantity were prepared periodically for winter study. These clams were killed and fixed by various methods which will be described later. Both those with the soft parts still in the valves and those removed from the valves were then stored in large-mouthed gallon jars.

Originally, floating cages for housing the experimental host fish were used in caring for the parasitic stages of the mussel but were later displaced by glass aquaria. The cages were arranged in linear series, with six individual cages composing a complete raft. The bottoms of the cages were constructed of zinc in order to allow careful examination of any bottom deposits. The sides and covers were of one-half inch mesh galvanized screen (Fig. 2).

Aquaria were of assorted sizes, varying from a capacity of one gallon, which were used as infecting chambers, to those of 10-gallon capacity for

containing the infected fish. The aquaria were of the usual type, with glass sides, steel frames and slate bottoms. The bottoms were made free of all irregularities so that any deposits could be secured easily.

Lake water was used exclusively during the determination of the fish host. It was pumped into the aquarium shelter where it was stored in a large overhead tank. From the tank the water ran continually as needed.

This study was conducted under the direction of Professor Frank E. Eggleton, of the Department of Zoology, University of Michigan. Invaluable aid, especially on taxonomy of the fresh-water pelecypods and bibliographical sources, was contributed by Dr. Henry van der Schalie, Curator of Mollusks at the University Museum of Zoology.

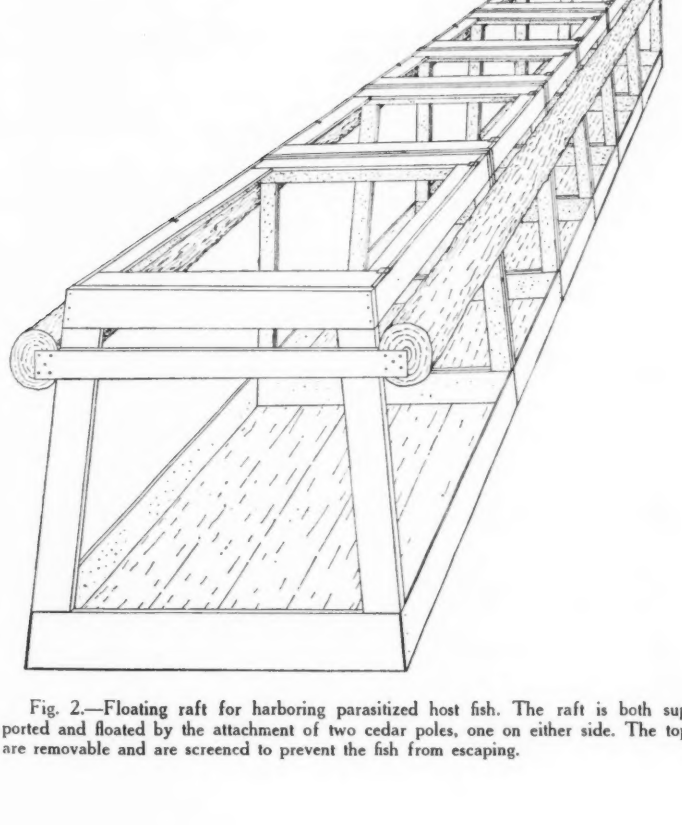
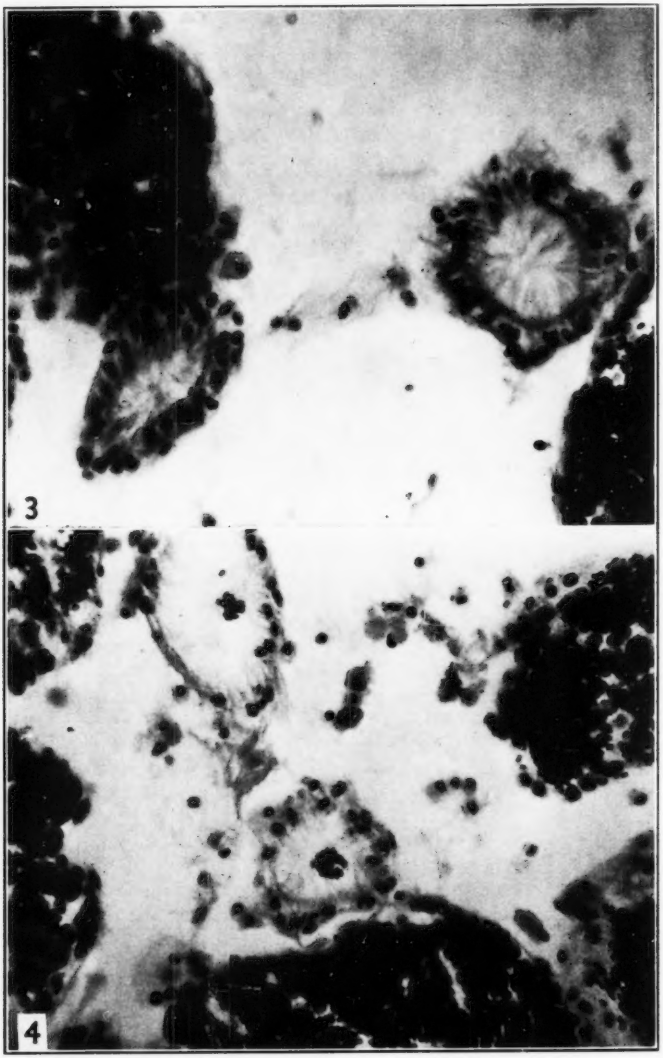


Fig. 2.—Floating raft for harboring parasitized host fish. The raft is both supported and floated by the attachment of two cedar poles, one on either side. The tops are removable and are screened to prevent the fish from escaping.



Figs. 3, 4.—3. Testicular acini and sperm ducts from mussel killed November 2. Two ciliated sperm ducts, devoid of spermatozoa, may be observed. 4. Testicular acini and sperm ducts from mussel killed May 2. Most of the germ cells at this time, just prior to the reproductive period, are spermatozoa. A thin rim of spermatogonia and spermatocytes is evident. The sperm ducts contain spermatozoa which are moving toward a suprabranchial chamber.

TECHNIQUE

The complete story of gametogenesis in *Elliptio complanatus,* and the subsequent phenomena concerned with fertilization and the clam's early embryology, is a complicated one. As a result, certain details, chiefly on gametogenesis, will be reported more in detail at a later time. However, all observations and results on gametogenesis described later in this paper are accurate and have been verified by several competent cytologists.

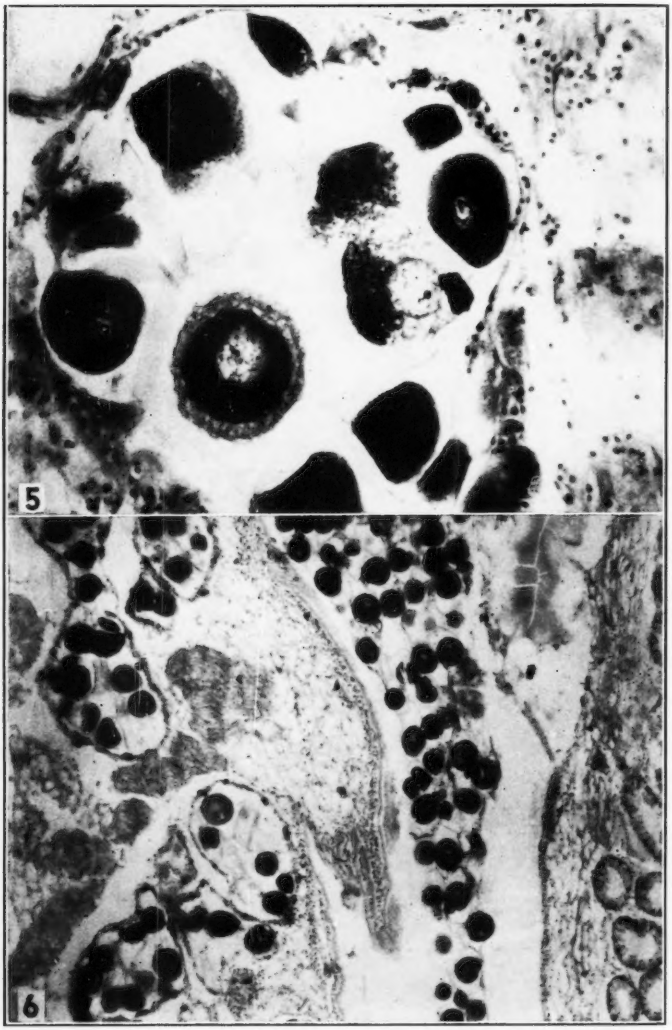
The basic stain used in all prepared slides for microscopic study was Heidenhain's iron-hematoxylin, which is specific for structures composed chiefly of chromatin. In various instances a counter-stain with eosin for cytoplasmic study proved profitable. Mallory's triple stain was also used. In general, however, the multiple stains often tend to be a hinderance because they mask underlying cells which can be easily studied when only the iron-hematoxylin stain is used.

GAMETOGENESIS AND FERTILIZATION

Fertilization occurs in the suprabranchial chambers of the female clam, as is customary among the various unionids. Viable spermatozoa, ejected into the water from the exhalent siphon by ciliary action and by the forcible closing of the valves of the male are able to swim considerable distances. Water movements also are probably significant in dispersing them. Eventually many of them reach the female. Here they are drawn into the mantle cavity through the inhalent siphon. After entering the ostia of the gills they are carried upward through the water tubes to the chief site of fertilization, the suprabranchial chambers.

Simultaneously with the above procedure the female reproductive cells have been propelled upward from the ovarian mass, through the various ciliated ducts, and thence into the suprabranchial chambers. At this time oögenesis has proceeded to the primary oöcyte stage. No further development occurs until a spermatozoon has penetrated the oöcyte.

As the immature ova are heavier than water they tend to drop into the water tubes. In *Elliptio complanatus,* only the outer gills serve thus as marsupia. Any of the ova which are not penetrated by spermatozoa in the suprabranchial chambers are very liable to meet sperm during their descent in the tubes. However, examination of the developing young in the marsupia has shown the presence of many unfertilized eggs in some specimens. This fact probably can be attributed, in these isolated cases, to a scarcity of spermatozoa at the time when the immature ova are in the proper location for penetration. Although impregnation is accomplished chiefly in the suprabranchial chambers, and to a certain extent in the water tubes, spermatozoa were observed in one instance in the ovarian ducts leading to the suprabranchial chambers. This would imply that sperm had been able to swim successfully against the influence of ciliary action in the ducts. Probably penetration could result. There is the possibility, however, that sperm had been forced into the ducts during the mechanical processes leading to the making of the slides.



Figs. 5, 6.—5. Ovarian acinus containing primary oöcytes during the process of increasing their cytoplasmic content. Several nuclei and stems are visible. A membrane which surrounds each reproductive cell is evident. 6. Ovarian acini during the passing of primary oöcytes into ovarian ducts. A duct is located at right center.

Many clams of both sexes were gathered and prepared for microscopic study during each week throughout the entire year. Also, specimens were often obtained at various times during subsequent years. The prepared mussels were then sectioned and examined microscopically. It was observed that, because environmental conditions vary on a specific date in successive years, only a close approximation concerning developmental stages to be expected could be predicted.

Examination of prepared slides showed that spermatozoa were present in the testicular acini throughout the year. The number of sperm present increased as the time of a new breeding season approached. For example, in the sections from clams killed in November the preponderance of reproductive cells was in stages prior to spermatozoa (Fig. 3). The sperm, if present, in a specific acinus usually occupied a position in the center at that time. In specimens examined which were killed on May 2, the greater portion of the cells were spermatozoa. Although no sperm were observed in the sperm ducts earlier in the male reproductive cycle, many ducts were filled in those killed on May 2 (Fig. 4). Some microscopic evidence from slides in the author's collection tends to show that the immature spermatozoa may spend more time imbedded in epithelial cells of the ducts which may act as sperm mother cells. However, this presumption must be verified and will be discussed in later papers. As the epithelium of all sperm ducts is ciliated, the journey of the spermatozoa to the suprabranchial chambers is thus facilitated.

Spermatozoa in *Elliptio complanatus* are viable throughout the year. This was proven by examining the fluid taken when mussels were vivisected. By inference it may be supposed that they are contained in the lumina of the testicular acini in the mature state until the time of breeding is at hand. Then, probably due to the environmental factors of increased water temperature and perhaps changed light conditions, certain physiological phenomena occur within the mussels, which cause ciliary action in the sperm ducts to be resumed.

Although there are individual differences between male clams, and climatic factors for different years may vary considerably, it may be said that spermatozoa begin entering open water in late April and continue to do so until the latter part of May, with a few isolated males shedding them as late as the middle of June. The period for maximum liberation of sperm is near the middle of May.

The germinative layer of the ovarian acini begins developing the female reproductive cells to the primary oöcyte stage much more rapidly than spermatozoa are developed during the reproductive cycle in the male. Within a few months the number of oöcytes is about as great as it is at the time of their liberation into the ovarian ducts. However, immediately after liberation only a very few primary oöcytes are contained in the lumina of the acini. Many may be observed in the process of taking on cytoplasmic material (Fig. 5). During this period they are attached firmly to the germinative layer of the acini by a definite stem. This stem persists for a short time after each oöcyte has gained full size and then the connection is broken. The area formerly occupied by the stem develops into a micropyle. At this time each oöcyte

is surrounded by a thin membranous covering which can be observed when subjected to eosin stain. It is very irregular, loose-fitting and noncellular. Its function and origin are as yet unknown to the author.

Evidence as to the time when the primary oöcytes pass into the ovarian ducts was obtained by miscroscopic examination of prepared slides. It was observed that no reproductive cells appeared in considerable numbers until the middle of May (Fig. 6). Again, as with spermatogenesis, we may assume that there are probably random examples of female clams which reach the period for profitable reception of spermatozoa previous to early May and perhaps as late as the last week of May or early June.

The liberation of spermatozoa into lake water by the male may be said to cover an appreciably wider time-span than the period during which primary oöcytes are in favorable position for sperm penetration in the female. Roughly speaking, the time-span of oöcyte exposure lies midway within that of the liberation of spermatozoa. From the standpoint of productivity this situation is fortunate.

Immediately following penetration of the primary oöcyte by the sperm, through the micropyle, a definite fertilization membrane is laid down by the cell membrane of the oöcyte (Fig. 7). As mentioned earlier, the micropyle lies on the area formerly acting as a stem for attachment to the germinative layer of the ovarian acini. After penetration by the spermatozoon the fertilization membrane at this point develops into a transparent chimney-like structure. Immediately surrounding this area the membrane adheres tightly to the cell. At all other points the membrane appears as a neat, loosely-fitting, transparent sac.

Very soon after the appearance of the fertilization membrane a very small body arises and is pinched off the main cell. This is the first polar body and signifies the transformation of the primary oöcyte into the secondary oöcyte. The second polar body is closely affixed to the first. The male and female pronuclei then combine to form the zygote.

PREGLOCHIDIAL DEVELOPMENT

The early developmental stages were studied with the use of living material. The material was obtained by opening the marsupial gills of over twenty females which possessed embryos in all stages from zygotes to mature glochidia. Because of the immense amounts of yolk material no attempt has been made as yet to study the mitotic figures involved during the cleavage processes. Observations made follow closely the results obtained by Lillie (1895, 1897, 1898).

It was observed that no cleavages occur while the zygotes remain in the suprabranchial chambers. They quickly settle in the water tubes of the entire outer gill where all further preglochidial development takes place. In a short time, probably several hours, the fertilization membrane loses its distinctive shape, breaking free from the zygote at all points. The chimney-like structure which marked the micropyle also collapses at this time. The polar bodies quickly disintegrate.

In *Elliptio complanatus* the entire outer gills act as marsupia. This fact is supported by literature and has been verified by direct observation (Fig. 8). As the water tubes of the outer gills are in direct connection with the suprabranchial chambers each tube becomes more or less filled with young. However, the upper openings of the water tubes composing the inner gills merely open into the mantle cavity at the place where the gills join the visceral portion of the foot (Fig. 9). This means that any water circulating through the water tubes, after entering through ostia from the mantle cavity, must again enter that cavity.

There are two possible ways for water in the cavity to leave: (1) by escaping between the mantles at some point; and, (2) by passing through ostia into the water tubes of the outer gills.

There is no direct evidence to prove whether water does escape through the mantles. Because of the location of ciliary tracts on the surfaces lining the circuit taken by the water as it proceeds from the inhalent to the exhalent siphon, we may assume that the amount of water escaping by this means is probably negligible. What seems more logical is that ciliary action in the upper respiratory areas causes lowered water pressure there by beating water from the suprabranchial chambers through the exhalent siphon. The water in the mantle cavity, then, in order to equalize the water pressure above, is forced, by its greater pressure, to enter the ostia of the outer gills. From there it passes among the eggs and eventually to the suprabranchial chambers,

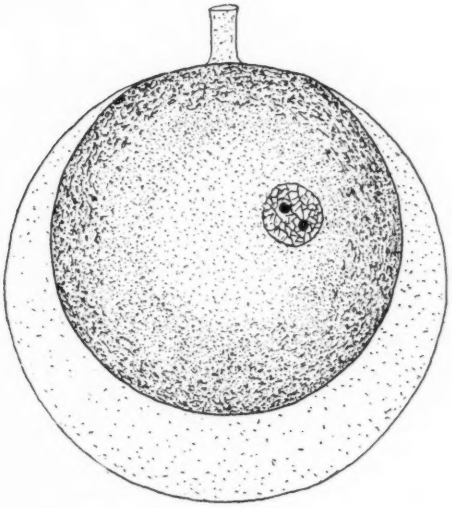
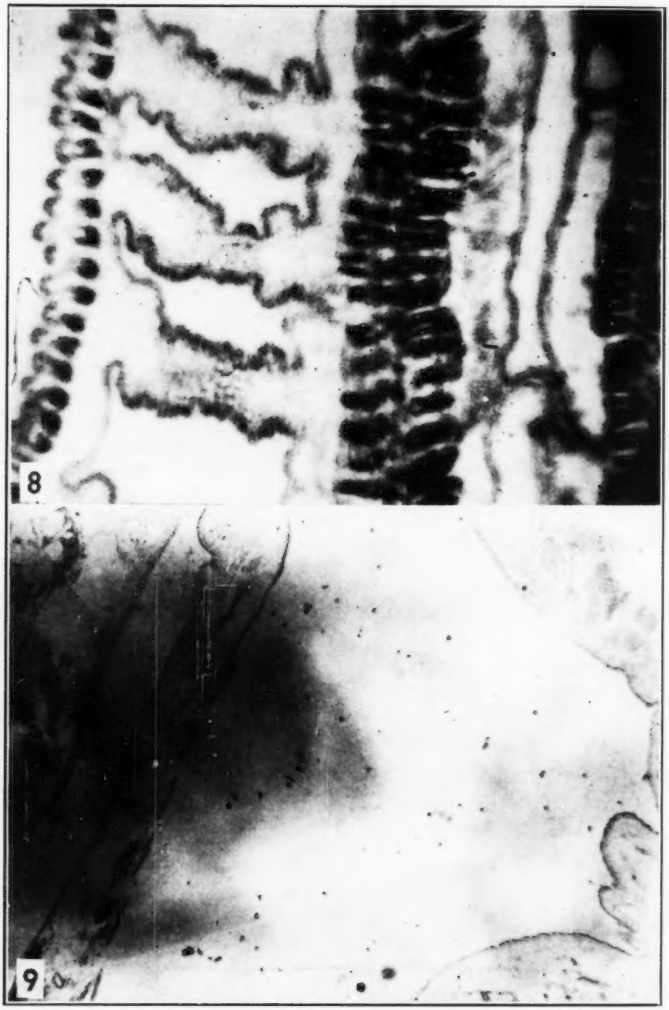


Fig. 7.—Zygote of *Elliptio complanatus*.



Figs. 8, 9.—8. Marsupial gill. The water tubes of the marsupial gill are square in appearance, while those of the inner gill are long and narrow. 9. Inner lamella of inner gill showing no attachment to the visceral portion of the foot.

thus equalizing the pressure. This would tend to be beneficial for several reasons. It would insure oxygenation of the eggs and the elimination of any toxic or waste substances in their proximity. Added oxygenation would be afforded the parent. Finally, wastes from the excretory and digestive tracts would be flushed from the common postanal region as usual. So, it is to the advantage of the female mussel to allow no water to escape through the mantle, not only for the embryos' sake, but also for her own. A suspension of powdered carmine placed in the mantle cavity, does not reappear until it leaves by means of the exhalent siphon.

In from seven to ten hours the first cleavage has been completed. The two resultant cells are unequal in size, one being considerably larger than the other. From then on the cells cleave quite rapidly until the blastula stage is reached. The number of cells present in the blastula probably approximates one-hundred and fifty. The gastrula stage has not as yet been identified in the material at hand. However, Lillie (1895) has described it in detail.

The volume of the developing embryo changes little, or none, from the zygote to the glochidium. All food needed for development is contained in the original primary oöcyte, with the possible exception that dissolved organic material might be absorbed. The possibility that food materials are transferred from the lamellae or interlamellar junctions of the marsupial gills of the mother is very slight. No special organs for attachment, or any kind of special secreting cells, have been noticed in any of the gill structures. Furthermore, although there is no shell formed around the egg, the fertilization membrane persists until the glochidium is completely mature. This structure prohibits the passing of appreciable amounts of nutritive materials from marsupium to the young, especially as the water medium is continually in motion.

Organogenesis is completed in approximately two weeks. The original fertilization membrane still persists as a loosely fitting sac. It is even present after the glochidia are capable of opening and closing their valves. When mature glochidia are shed normally by the female, however, it has always been observed that the larval clams are entirely devoid of the membrane. How this membrane is lost is unknown.

It is not unusual to observe clams aborting their young. This is accomplished either by exuding the ovisacs in an intact state, or, as is habitual with some species, as fragments. Abortion is usually caused by various undesirable situations such as sudden changes in water temperature, rough handling, the presence of toxic substances in the water, and starvation. The tendency toward abortion is highly variable among the different species of clams.

The incidence of abortion among females of *Elliptio complanatus* is high as compared to most clams. The ovisacs are expelled in an intact condition, each ovisac retaining the shape of the extended water tube which it formerly occupied. During the period when embryonic development was in progress, clams were often brought from the supply lake to the laboratory in tubs, usually for the purpose of infecting fish. Invariably, after the clams had been removed from the tubs, the residue would contain great numbers of the

aborted ovisacs. There seems to be no discrimination as to the degree of development of the young, as all stages are represented. This condition has been observed among members of *Elliptio complanatus* in their normal habitat.

GLOCHIDIAL STAGE

When the young of any clam are ready to be expelled from the marsupial gills of the female they may be termed mature glochidia. In some species of clams they are shed while the ovisac is still intact; in others, as individuals. Again, some species shed only mature glochidia, whereas, in others they are given off along with immature ones which perish. However, according to Ortmann (1911), this condition is quite unusual among clams. In any case the occurrence of a considerable number of undeveloped or unfertilized eggs in the marsupia is inevitable. These are liberated with the glochidia.

After much observation, it was concluded by the author that normally the glochidia of *Elliptio complanatus* are expelled from the exhalent siphon, not united in ovisacs but individually. A certain amount of mucous is secreted simultaneously, producing a cob-web-like structure in which strands of mucous are suspended from any projecting surfaces, with the active glochidia arranged at random wherever they happened to come in contact with it. This arrangement is a decided asset in securing a fish host. When glochidia are ejected into water which is devoid of projections they fall freely to the bottom. There is no evidence of a byssus on the glochidium of *Elliptio complanatus* (Fig. 10).

It is noticed that when a female spawns prematurely, due to some disturbing factor, the glochidia often emerge united as small fragments of the original ovisacs. Usually upon examination one finds that in such a mass there will be many representatives of earlier stages, as well as viable glochidia present in the structure. This may account for Ortmann's statement (1911) that the glochidia of *Elliptio complanatus* are shed as ovisacs. The examination of large numbers of aborted ovisacs has seldom shown any mature glochidia present, and these have always been retained in the egg membrane. Judging from the above observation, it seems that in *Elliptio complanatus* the embryos do not necessarily develop at an identical rate, but that those which are mature are held in the water tubes normally until most have reached that stage.

All factors being normal, the time required for the development of the young of *Elliptio complanatus* from fertilization to mature glochidia is roughly one month. Although generic differences are without doubt highly important, environmental conditions also definitely alter the time taken for development. Probably the most important influence is temperature. Both the time of fertiliaztion and the length of the developmental period are affected by this factor. During the summer of 1945, the author opened a large number of clams, starting the procedure soon after the theoretical breeding period, and continuing far after the so-called normal spawning period had ended. He found only one female who had mature glochidia. The mean water temperature for that summer was considerably below average. The fate of the immature stages was never determined, although many probably were aborted in a still undeveloped condition.

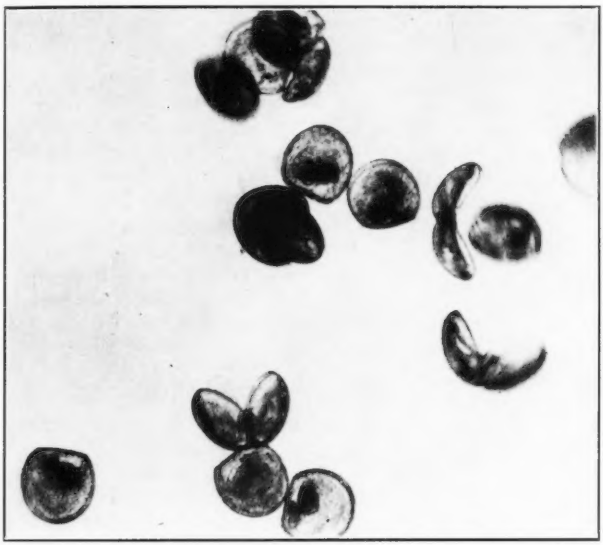


Fig. 10.—Glochidia of *Elliptio complanatus*.

During the summer of 1943, the following observations were made on the developmental stages of *Elliptio complanatus*. On June 30, out of sixteen experimental clams, both male and female, two females were in the process of shedding glochidia, and one possessed both glochidia and earlier stages. From July 4 to July 7, many clams were opened and approximately ninety per cent of the gravid females possessed either nearly mature or mature glochidia. On July 7, twenty-five were taken from shells and preserved for future study. Out of twelve females, three possessed glochidia and one possessed an earlier stage. On July 14, twenty-five more were preserved and no gravid ones were found. Each week, until August 3, twenty-five additional ones were preserved. No gravid clams were found in these groups. The mean temperature of the water from June 27 to July 7 was 22.5°C.

During the summer of 1944, the following results were obtained: On June 15, ten clams, both male and female, were preserved. Four females possessed very early developmental stages. From June 16 to June 19, the clams examined from the supply area in Douglas Lake possessed many very early stages. A considerable portion of those females gathered and placed in aquaria aborted their young within several hours.

On June 23, the first clam to shed viable glochidia was noticed. It had been collected that day from Ocqueoc Lake, in which *Elliptio complanatus* is native. From June 23 to June 29, the greater portion of female clams were shedding viable glochidia. On June 22, twenty clams chosen at random were

opened for preservation. Of these, five possessed mature glochidia and one possessed earlier stages. The rest of the females had spawned. On June 29, ten were opened and none were gravid.

Although during the summer, seventy additional clams were opened in the laboratory and preserved at intervals of three days, no others were found in the gravid state. However, on July 12, one with viable glochidia was discovered at Ocqueoc Lake after opening thirty-eight clams. The mean temperature of the water from June 27 to July 7, 1944, was 24.0°C.

The scarcity of mature glochidia during the summer of 1945 has been discussed in an earlier paragraph. The mean temperature of the water for the period of June 27 to July 7 for this latter summer was 20.9°C. Because this very unseasonable weather extended through most of the summer, the majority of the other aquatic animals, as well as the plants, was greatly retarded in development. The significance of unusual aquatic temperature conditions is great and is often overlooked.

From the preceding data, we notice that in 1943 there was evidence of spawning among *Elliptio complanatus* from June 30 to July 7, with one clam possessing immature stages on the latter date. In 1944, the first evidence of spawning was found on June 23 and the last, one shedding clam, was located with great difficulty on July 12. The majority had completed the process by June 29. Therefore, it is evident that the spawning season for *Elliptio complanatus*, in the Ocqueoc River system, extends from the middle of June to the middle of July, with very little shedding before or after this period. Incidental observations for several years support this statement.

The period of spawning mentioned above applies, in general, only to that portion of the range of *Elliptio complanatus* which lies from the St. Lawrence River Valley westward. Other writers have given data on the time of spawning elsewhere. Ortmann (1911) states that glochidia have been found as early as June 7, and discharging females have been observed on June 7 and 13, and on July 9 and 11. Conner (1907) states that the breeding season may extend to August. F. C. Baker (1928) mentions the breeding season as extending from the last of April to the middle of May, but does not mention when spawning comes. Lea (1863) found *E. complanatus* gravid in May. Probably all of the above data apply to the Atlantic seaboard, although specific localities are not reported.

Some observations were made on the tolerance of glochidia of *Elliptio complanatus* of certain adverse conditions. Sudden changes of temperature were lethal. The glochidia die after a few moments of dessication. On June 30, 1943, the mature glochidia of one clam were placed in a petri-dish filled with lake water. It was then placed in a refrigerator set to maintain a temperature of 4.5°C. They became active when re-examined on July 6. Again in 1944, another sample was placed in the same refrigerator on July 1. On July 3, they were used for infecting fish. The ability to withstand cold to the extent of remaining viable for several days may be common to other unionids. If so, this may prove valuable in the raising of clams which have economic importance.

PARASITIC STAGE OR METAMORPHOSIS

The glochidium is small in comparison with those of other mussels. It is hookless; its length is either slightly greater or equal to its height; and it is subovate in form (Fig. 10). It measures about 0.20 mm. in length and 0.19 mm. in height.

Glochidia must be ejected upward into the water by the female clam in order that they may meet their fish host. This is accomplished normally by water currents created by the action of cilia located on the walls of the respiratory tract. The siphons do not seem to be modified for attracting fish, as is the case among some mussels. The larval mussels of *Elliptio complanatus* may be observed as many tiny particles steadily flowing upward in the water from the exhalent siphon to a height of about seven inches. They are mixed with fine strands of mucous and waste materials. As mentioned before, if the substratum possesses projections of any type, the mucous becomes anchored thereto, and forms a cob-web-like structure on which glochidia become lodged. If no prominences are present, they slowly fall bottomward. Normally, the glochidia are now devoid of any enclosing sac.

At times the valves of the female close forcibly causing the glochidia to be ejected into the water to a greater height. This reflexive behavior is probably caused by the clam's reaction to ruptured egg membranes and mucous in the suprabranchial chambers, as well as the normal excretions.

Both the volume and velocity of the water escaping from the exhalent siphons of any unionid is often under-estimated by the casual observer. Invariably any clam of average size can create definite surface currents when located a foot or less under the surface of quiet water. In fact, during normal respiration a clam at this depth often may eject a stream which elevates that area of water directly above it higher than the surrounding water. One commonly notices clams squirting water into the air when their water cover has been removed suddenly. The mussel must depend on the water circulating through the valves for food-getting, excretion of all wastes, introduction of the sperm to the egg, and placing the glochidium in a position to contact a possible fish host.

During the first attempts at finding the possible fish host, or hosts, for *Elliptio complanatus*, floating cages were used to provide the necessary compartments for harboring the paratisized fish. The principle of utilizing floating rafts as used by Coker, Shira and Howard (Howard, 1922) in their experiments on the life cycle of *Lampsilis siliquoidea* on the Mississippi River was copied in modified form (Fig. 2). Six cages were placed in linear series and made into a raft by fastening a dried white cedar pole on either side which also added buoyancy. The bottom dimensions of the cage were four feet in length by three in width, while the top measured four feet in length by two and one-half in width, with the height two feet. All sides, as well as the movable top, of each cage were covered with one-half-inch mesh galvanized screen. The bottom was made of zinc sheeting and the sides possessed a three-inch barrier at the bottom to prevent the loss of young clams which might have otherwise escaped over the sides. The differences between

top and bottom dimensions also were designed to prevent loss of young as they dropped from the fish to the bottom. Two such rafts comprising a total of twelve cages were constructed.

At the same time, twenty-five aquaria ranging from two to ten gallons in capacity were set up in the aquarium shelter to act as housing for other infected fish, and as a safety measure in case the floating cages were unsatisfactory. As mentioned previously, they were cleaned of all foreign particles and the cement along the sides of the bottom was trimmed level with the glass. Each aquarium was numbered, as were the units of the rafts. A constant supply of surface lake water from a supply tank was allowed to enter the aquaria as needed.

Three aquaria, each with a capacity of ten gallons, were first used as parasitizing chambers. As *Elliptio complanatus* does not show sexual dimorphism, about thirty clams of this species were placed in normal position in each chamber in the hope that several would begin to shed glochidia. They were placed there before any spawning of *Elliptio complanatus* had been noticed for that season.

The smaller species of fish to be used as possible hosts for the glochidia were netted. The larger ones were caught on hook and line. The barb of the hook was filed off and the fish caught were placed immediately in large tubs of lake water which were carried in the boat. No dry objects were allowed to touch them during transference to the tub. They were allowed to disengage themselves from the hook. If any captured fish had any encysted glochidia, or other foreign objects on either gills or fins, it was discarded. The gills and fins of the fish were examined under water with the aid of a hand-lens. Encysted glochidia appear as small light-colored tubercles. Once a glochidium is encysted it is very hard to identify.

As soon as spawning was in evidence, all available species of fish which occupied the same environment as *Elliptio complanatus* were exposed in small groups to the glochidia. Each species was represented by a minimum of six fish. As soon as suitable exposure had been experienced by the fish, they were placed in their respective compartments for study in anticipation of the possible dropping of immature mussels. The gills of all fish were examined before being placed in their containers to see that glochidia were present in suitable numbers on the gill filaments. This was done by placing the fish to be examined in a glass container full of water. The gills were gently opened and the filaments were then examined under a binocular dissecting microscope. Each species was assigned to a certain container. Clean, water-soaked sticks were placed as barriers in the cages of those fish which habitually quarrel with each other.

There is evidence that the fish experience an unfavorable reaction from the initial attachment of the glochidia. This is possible true when the glochidia of other species of mussels become attached to fish, especially among those types which possess hooks on the valves and attack both fins and gills. The glochidia of *Elliptio complanatus* are hookless and survive usually only on gill filaments. Within a few minutes after being inserted in the parasitiz-

ing chamber the fish, although quiet originally, would begin to dash blindly about the chamber for several moments. Then it would place its head as far as possible into a corner, or among the mussels, and from then on lie in a rigid condition until removed. Upon examining the gills microscopically, on exposed fish, it was discovered that a great portion of glochidia located on the gill filaments had pinched the arteries until the flow of blood was discontinued. This probably caused considerable physical discomfort to the fish. Any fish which died from over-infection did so with the gill-plates extended at the time of death. The chief cause of immediate death was asphyxiation. The amount of exposure which would not prove too harmful to the fish was never determined while the above method of infection was used, because the supply of glochidia could not be controlled. Usually two minutes were enough to cause suitable infection with little harm to the host. It has been discovered by other workers (Coker, Shira, Clark, and Howard, 1921) that certain fish can act as host to as many as 2,500 of their specific glochidia without lethal effects. Murphy (1942) found that 42 mm. average length rainbow trout (*Salmo gairdnerii*) could carry 600-1200 glochidia of *Margaritifera margaritifera falcata*) with 52 per cent mortality. No accurate data of this nature were obtained for the only species of fish which was proved to be the host for glochidia of *Elliptio complanatus*, but the author is positive that several hundred could be maintained without lethal effects upon the fish.

Although asphyxiation was the chief cause of immediate death, most of the deaths resulted from secondary infection caused by water mold (*Saprolegnia*). An attempt was made to combat this disease by several methods. The rafts were sunk to a depth of twenty feet where a temperature of about 15°C. was reached but where sufficient oxygen was present. However, the cooler temperature failed to keep them from dying. For example, out of sixty parasitized perch, thirteen remained. It was discovered that the parasitized fish fared much better in the aquaria, especially if the supply of running lake water was eliminated. The water temperature dropped to about 18°C. The reason for this improvement is still unknown, although *Saprolegnia* does not thrive at lower temperatures. There is also the possibility that it could not maintain itself without an outside supply and thus disappeared.

Table I shows a list of the fish infected and the results obtained from the parasitization. All fish except those deliberately killed and examined were kept even after all viable glochidia had disappeared. They were killed and examined periodically until the supply was exhausted.

It is evident that the yellow perch (Table I) is the only fish of the tested group which serves as the natural host. There is the possibility that some fish in the Ocqueoc River drainage system, which is not included in the list, may be an equally satisfactory host. Other unionids may have one or more fish hosts other than their specific one. Then there is the possibility that some fish, perhaps closely related to the perch, but foreign to the habitat studied, is acting as the host elsewhere, for example, on the Atlantic seaboard.

A check on the distribution of the yellow perch indicates that it has a general east coast range down to North Carolina, and that it cuts across the northern states from New England to northern Indiana and Illinois on to Wisconsin, Minnesota and Iowa. As this mussel covers oly part of the area occupied by the yellow perch, there is the chance that it will someday further extend its range.

TABLE I.—Experimental fish and results of parasitization by glochidia of *Elliptio complanatus*.

Number of fish	Species of fish	Period of glochidial attachment	Final condition of host
6	Largemouth black bass (*Huro salmoides*)	5 days	satisfactory
6	Northern smallmouth black bass (*Micropterus d. dolomieu*)	8 days	satisfactory 2 died during infection
20	Northern rock bass (*Ambloplites r. rupestris*)	2 days	satisfactory 1 died during infection
6	Northern logperch (*Percina caprodes semifasciata*)	5 days	1 died while parasitized
80	Yellow perch (*Perca flavescens*)	full term 18 days	59 died, 20 of parasitization
6	Common bluegill (*Lepomis m. macrochirus*)	1 hour	excellent
6	Great Lakes longear sunfish (*Lepomis megalotis peltastes*)	1 hour	excellent
6	Pumpkinseed (*Lepomis gibbosus*)	1 hour	excellent
6	Bluntnose minnow (*Hyborrhynchus notatus*)	3 hours	all died in 6 hours
6	Northern common shiner (*Notropis cornutus frontalis*)	unknown	all died while parasitized
6	Iowa darter (*Poecilichthys exilis*)	2 hours	4 died of parasitization
6	Johnny darter (*Boleosoma n. nigrum*)	1 hour	4 died of parasitization
160	Total		

The perch, although infected during a period of several days, all carried the glochidia about the same length of time: eighteen days. It was surprising to discover how closely the length of the parasitic stages coincided in various specimens. As a rule, one day elapsed between the time when young clams could not be found on the floor of a container to the time when the gills of the fish were quite bare. The fish were exposed to glochidia during the period from June 23 to 27, 1944.

The bottoms of all cages were examined daily throughout the summer, in addition to any experimentation of a nature similar to that described in the preceding paragraph. However, if it was discovered that any cage contained freshly dropped clams, its bottom, and the fish, were examined more frequently. The young were secured from the cages by means of a small suction pump, with a hose attached so that one could vacuum-sweep the bottom. The bottom materials were collected in buckets and the young were found in the laboratory by hand-sorting under a binocular microscope. The bottom materials in the aquaria were siphoned out by means of a rubber tube and then examined in the same manner as were those from the cages. The young discovered during each day were placed in separate containers for future study.

The 160 fish which were parasitized during the period from June 23 to 27, 1944, were distributed among the twenty-five aquaria and the twelve cages previously mentioned. On the morning of July 10, none of these experimental fish had yet shed any immature clams; but a considerable number of them had died by that time. Among the surviving hosts, all except the yellow perch had lost their glochidial infections.

As a safeguard, a special trip was made to Ocqueoc Lake and a determined search for gravid clams was conducted in that body of water. The thirty-eighth clam examined proved to have its gills distended with viable glochidia. The importance of this discovery, so far beyond the usual date for cessation of spawning, and the improbability of finding another gravid specimen prompted an immediate and hasty return to the laboratory.

It should be recorded, in passing, that the clam had been partially dissected in order to discover its condition, and that it had to be transported nearly fifty miles before its glochidia could be utilized for further experiments. Furthermore, in order to prevent loss of the glochidia, the mussel was carried back wrapped only in a moist cloth. Upon return to the laboratory, a fresh supply of approximately 100 yellow perch was secured from the lake as rapidly as they could be caught. All these fish were immediately exposed to the glochidia by the artificial method described in the succeeding paragraph. Twenty of the experimental fish were placed in aquaria, each of which eventually contained only two. The remaining perch were placed in tubs. The cages were used as containers for immature mussels which were to be left undisturbed. The keeping of parasitized fish in them was discontinued because *Saprolegnia* was uncontrollable in them, they were clumsy to manipulate, and they were too far from the laboratory. The parasitic stage again required about 18 days. The following year, 1945, the procedure was repeated with no difficulty, using the one available shedding clam as the source of all glochidia.

A new technique was used in parasitizing the perch with glochidia on July 12, 1944, and again in the succeeding year. A very small aquarium, barely longer than the largest fish, was used. It had been cleaned of all foreign material. The fish to be parasitized was then placed in the water. It was given sufficient time to become quiet. Then the purest possible concentration of glochidia, which had been obtained from an opened female clam ready to shed, were slowly and cautiously placed directly in front of the fish's mouth with a pipette. By this method, one could eventually estimate very closely the number of glochidia used for each fish. However, an attempt at a quantitative study was not made by the author at that time. Usually about one drop of water full of glochidia was used for each fish. Any glochidia falling to the bottom might later be taken in by the fish. The glochidia were usually viable even after lying on the bottom for at least a day. Murphy (1942) states that glochidia of *Margaritifera margaritifera falcata* remained alive for eleven days in a container. One decided advantage of this method over the former one is the fact that there is no danger of over-parasitizing the host, and, as a result, it can be left in the aquarium indefinitely.

Where glochidia are introduced artificially, one can ascertain the degree of their viability by jarring the container. They immediately begin to open and close their valves. It was also observed that they are highly sensitive to the materials which exude from torn fish tissue. A small amount of such material introduced on a scalpel blade causes them to perform the opening and closing reflex with great vigor.

The glochidia of *Elliptio complanatus*, as mentioned before, are hookless. That is why they are primarily found on the gills of the host. They often fasten to fins, and even scales, but none were observed to survive to maturity in such places. Tucker (1927) states that the hooked glochidium of *Anodonta imbecillis* usually fastens to the fins of the host fish. The hooked-type glochidial valve may cause considerable damage to the tissues of the gill filament. Microscopic examination showed that the successful attachments are made where the valves of *Elliptio complanatus* clamp onto a substantial piece of gill filament. Often an artery is blocked by the pressure. The epithelial tissue and stroma are mutilated by the edges of the valve. Arey (1932) states that the scar tissue which attempts to cover the wound, and which in doing so encases the glochidium, is not created by mitotic division and proliferation of the intact cells bordering the injury, but by their migration over the area to be covered. The time required for complete encystment was from two and one-half to three hours. Although rough and irregular when first completed, the cyst wall becomes smooth and thinner in a few days (Fig. 11).

The glochidium does not gain in size during the parasitic stage. This seems to indicate that the function of parasitism in *Elliptio complanatus* is not only to secure an easily available food supply during metamorphosis, but also to be in a position of safety during a time when it is unable to cope with a diverse and perhaps unfriendly environment. However, considerable growth must occur among certain species during the encystment period.

Murphy (1942) reports a 660 per cent increase in length of the encysted larvae of *Margaritifera margaritifera falcata* while in the rainbow trout. Tucker (1927), while working with *Anodonta imbecillis* in the green sunfish (*Apomotis cyanellus*), mentions "only a slight increase in size due to a small shell growth. This consists of a 'narrow rim around the edge of the glochidial shell' (Howard 1915)."

In the encysted glochidia, organogenesis is not completed until late in the parasitic stage. This is evidenced chiefly by the persistence of the single adductor muscle. However, during the last week metamorphosis proceeds rapidly, and, a day before being dropped, the young mussel can be seen moving about inside the cyst wall. Finally, both by movements of the valves and by normal disintegration of the cyst wall, the immature clam is ready to begin an independent life.

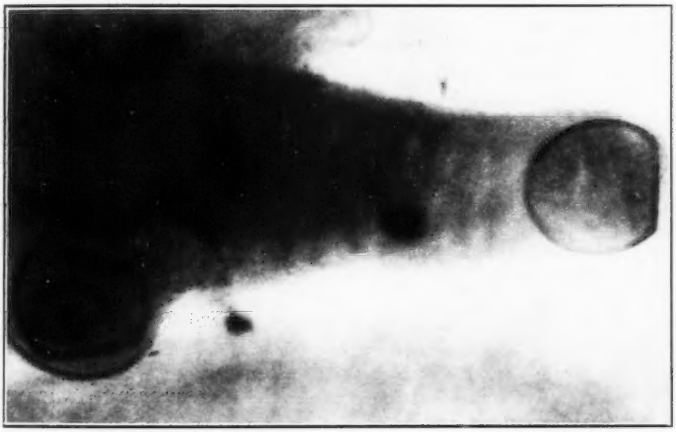


Fig. 11.—Encysted glochidia of *Elliptio complanatus* in gill filament of yellow perch. The cyst had been formed eight days.

DEVELOPMENT OF THE IMMATURE MUSSEL TO ADULTHOOD

The newly dropped immature clam possesses only the glochidial valves (Fig. 12). However, its internal anatomy is entirely altered. It now possesses very evident anterior and posterior adductor muscles and gills, which may be seen through the valves, a liver, and a very remarkable foot. The gills are in the form of papillae, with several on each side of the foot, the longest being located anteriorly. Howard (1922) and Tucker (1927) bear this out by their observations. Other structures found in the adult are not visible but are possibly present.

The foot of the young clam is extremely long and narrow, and can be

extended to a length equal to at least twice the height of the valves. The end of the foot is heavily ciliated and seems to possess adhesive qualities. When it is being extended, the cilia beat violently in a rhythmic manner; but, when at rest, the ciliary action ceases. Then, by contracting the foot, the body is dragged toward the ciliated portion. This procedure is repeated and the young clam moves with comparative ease. Howard (1922) states that an immature clam of this age possesses a bilobate foot. This was also observed in *Elliptio complanatus,* which accounts for its adhesiveness.

No final conclusion could be drawn as to the type of food which is eaten at this stage of development. The normal food of a free living clam (Allen, 1914, 1921; Churchill and Lewis, 1924), such as diatoms, protozoans, detritus, and other items, is perhaps half as large as the young clam. None of the common items of the adult's diet were seen to be ingested by the young. Water not only enters the inhalent siphon at this stage, but also along the full length of the ventral edges of the valves, which normally remain partly open. Some organisms, chiefly *Ceratium,* became partially enclosed by the open valves at various times, later to be forcibly ejected by water currents and the shutting of the valves. There is the possibility that the young of this species may utilize considerable quantities of bacteria and dissolved organic material at this stage. It must be remembered, in this connection, that the members of the subfamily Unioninae are considerably smaller, in the glochidial and post-glochidial stages, than are those of Anodontinae and Lampsilinae. This fact may account for the failure of the young of *Elliptio complanatus* to utilize the larger plankters as food.

In order to study growth increase, ten immature clams were selected and measured for length as soon as they were dropped. They were then isolated in finger-bowls supplied constantly with lake water, and were measured later at various times. It was hoped that they would be able to secure as much food with this arrangement as they would in nature. It is suspected, however, that this was not the case, as the intake pipe for the water supply was over a foot above the lake bottom. Table II shows the average measurements which signify increase in length.

By providing a constant supply of lake water, the immature mussels were kept alive beyond 35 days. Shortly after this period all died from the effects of being moved to a new location. Lefevre and Curtis (1910) were able to keep alive *Lampsilis ligamentina* and *subrostrata* for a period of six weeks.

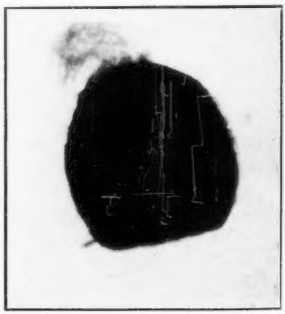


Fig. 12.—Immature mussel within one hour after dropping from the host fish. The foot is extended from the shell.

TABLE II.—Average lengths of the immature specimens of *Elliptio complanatus*.

Age in Days (when dropped)	0	7	13	21	35
Length in Millimeters	0.208	0.297	0.518	0.572	0.840

It is logical to believe that, if one were well enough acquainted with the habits of the yellow perch, he could locate the young clams quite easily. Since Ocqueoc Lake is a habitat in which *Elliptio complanatus* abounds, it was chosen as the site for finding the juvenile stages. A great portion of the shore line possesses an extremely narrow shelf which borders a very steep declivity. It was noticed that great numbers of perch inhabit the area of water near the upper limits of the inclined substratum. With this fact in mind, both Ekman and Peterson dredges were used in taking many bottom samples from what appeared to be ideal locations. As a matter of course, bottom samples were also secured from areas farther from shore, at a depth of about twenty-one feet, where the declivity had ceased. The samples were carefully screened, then taken to the laboratory, where they were hand-sorted. No evidence of juvenile clams of any growth stage were found. Indeed, no specimens less than 0.75 cm. in length have yet been found by the author. In the fall of 1945, one specimen which measured 0.75 cm. in length was discovered by screening bottom materials in shallow water where many adult clams were congregated. In all, only three specimens of this size have been located in nature during the time spent working on that phase of the problem. Also, very few can be found which are under four centimeters in length. During the same time only eight individuals of that size were collected. As *Elliptio complanatus* attains the length of about one centimeter during the first year, according to a study of the umbo of an adult, the one measuring one centimeter must have been dropped at the end of the summer during which it was found.

The rule seems to be that the availability of the mussels varies inversely with their size. This probably is true for any species of clams. It is the author's opinion that the scarcity of young stages is not hard to understand. The fresh-water mussel is a striking example of an animal which must produce many larvae in order to maintain the adult population. It has been stated that a female specimen of *Lampsilis gracilis*, 7.4 cm. in length, yielded 2,225,000 glochidia (Coker, Shira, Clark, and Howard, 1921). A great portion of these, perhaps all, are lost unless the fish host is present in considerable numbers at an opportune time. Of those which strike the fish, many attach in unfavorable positions, especially if they are of the hookless type. Of those which do attach satisfactorily, some are lost by faulty encystment. If the immature mussels drop upon an unsuitable bottom, which is liable to be the situation, they must die. If a favorable bottom is encountered, the young mussels must travel to that depth of water which is best suited for them.

There are many pitfalls along this path. However, if they do reach their permanent location, and can increase in size to the extent that they cannot easily be destroyed, they then live to a relatively old age encountering few hazards.

It has been found that the growth of a clam is not directly proportional to its age. After the third year, the amount of new shell material deposited each year in *Elliptio complanatus* diminishes. Isley (1914) supports this conclusion. After the twelfth year of age, the added amount is hardly noticeable (Fig. 13). This species adds the largest mass to its shell during the third growing season, and next largest, during its second year. Sexual maturity is reached at least as early as the end of the third growing season.

According to literature, *Elliptio complanatus* exhibits no sexual dimorphism. However, there is great variation among different examples of this species in regard to height of the marsupial ridge and body width. By using these features as criteria, the determination of sex was attempted. The soft

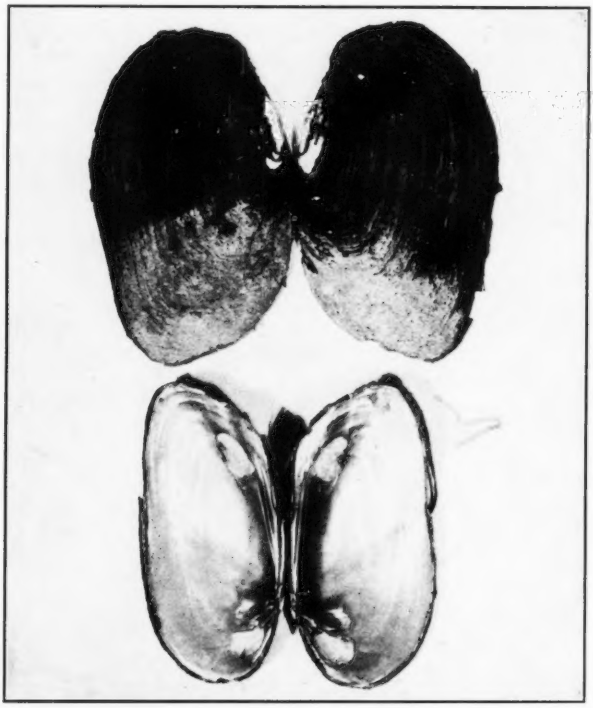


Fig. 13.—Valves of mature specimen of *Elliptio complanatus*.

parts from 150 adults had been preserved previously for later microscopial examination for several purposes, one of which was a study of gonad tissue. The empty shells of these were used to etsablish the reliability of sex determination by valve characteristics. The author and several others, working separately, attempted to identify the shells as males and females. But, upon determining the sex definitely by microscopical examination of the gonad tissue, it was found that there was absolutely no correlation between the original designation from the shell characters and the true sex, proving that *Elliptio complanatus* shows no trace of sexual dimorphism, so far as shell characteristics are concerned. Incidentally, 78 were males, 71 were females, and one was hermaphroditic, with ovarian tissue predominating. According to literature this species is dioecious. The single hermaphrodite, therefore, was unusual.

GENERAL ECOLOGY

Elliptio complanatus does not discriminate between a lake and a not-too-rapid stream, judging from the data afforded by the habitats under observation. Ocqueoc Lake* may be termed a river-lake in that the Ocqueoc River flows into one end and out the other. The lake is about one-half mile wide at its widest point, and is about one and one-half miles in length. The current in the lake is not noticeable. *Elliptio complanatus* can be found any place on its periphery in varying numbers, other than on the short stretches where a muddy substratum is present. Most of those found in the lower river are either immediately where lake becomes river or within 100 feet downstream from this area. The water averages about four feet in depth within these boundaries. The river population of this mussel finally ceases about 200 feet from the outlet of the lake. This is probably due to the shallowness of the water and increased velocity of the current.

One interesting point observed was that three other common species, *Lampsilis siliquoidea, Anodonta grandis* and *Ligumia nasuta,* occupied the shelf above the declivity, whereas *Elliptio complanatus* was rarely found there. The first three were almost entirely absent from the whole face of the declivity, which usually extended from three or four to about six feet in depth. *Elliptio complanatus* was normally a resident there. The temperature varied considerably between the shelf and the upper part of the declivity.

The bottom where *Elliptio complanatus* is most abundant is composed chiefly of clay, mixed with marl and fine sand. The reason for this preference is not clear. The mussels are not plentiful on a sandy bottom. No shoreline which is predominantly composed of marl is present on the periphery of the lake. Therefore, it is not known whether the mussels live in this type of bottom. As stated before, they do not relish a mud bottom, probably because their heavy shells sink into the substratum. It is not unlikely that the habits of the perch themselves may determine in large measure the size of population in a bed. Stability of shoal seems essential, but to date there is very little

* Locus Key for Ocqueoc Lake, Presque Isle County, Michigan (Tier 36N, Range 3E, Section 30).

experimental evidence as to the relative significance of the various specific components.

Elliptio complanatus lives at a depth relatively greater than most of the common mussels of northern Michigan. They seem to prefer a depth of 3-5 feet. Baker (1918) reports them at a depth of 5 feet in Oneida Lake. In the same lake he (1916) also reports them 2-3 feet on a hard sandy bottom. It seems probable that temperature of the water is, either directly or indirectly, an important factor in this distribution. The dispersal of mussels is somewhat stratified on the face of the declivity. Marked individuals, placed in relatively deep water in late summer or early fall, usually have returned to the selected stratum by the following spring. Those placed in water shallower than the optimum also migrate to the proper level in a very short time, usually in a matter of a few hours. Water warmer than about 24°C. usually will cause them to wander indiscriminately. Because they exhibit positive geotaxis, they eventually reach cooler water. When they reach a depth where the temperature is at, or near, their optimum the influence of geotaxis becomes less powerful than that of thermotaxis and they remain at the new level. Those thrown into deeper water migrate back up the slope to the optimum level because the combined influence of lower temperature and greater pressure is enough to overrule their positive geotaxis. Moffett (1943) found that certain species of mussels were greatly affected by wave action. This factor may also influence vertical distribution.

A vertical temperature series taken in the open water far from shore may show an epilimnion practically homothermous to a depth much below the level selected by the clams. However, a similar series of temperature deteralong the slope of the basin, will exhibit lower temperatures at much higher mination taken at the same depths, but close to the surface of the bottom levels. This is especially true in a lake, such as Ocqueoc, where many small springs pour colder water into the lake along the face of the declivity. In Ocqueoc, these cold springs were much in evidence when clams were being collected along the declivity. Even in a lake where such springs are not known to be present, it has been shown that there is some difference between physico-chemical factors along the slope of the bottom and at the same levels out in the open lake but far from shore (Eggleton, 1931). Therefore, it is evident that the vertical temperature change occurring on the substratum occupied by mussels may be more pronounced than in the open water of that body of water.

TAXONOMY AND DISTRIBUTION

Elliptio complanatus (Dillwyn) 1817 is one of the most prominent species of the genus. Hass (Vid. Middel. Dansk Naturh. Foren., LXV, 1913, p. 54) revived the name *Unio violaceus* Spengler (1793). However, Walker (1918, p. 3) stated that *violaceus* failed to describe the species sufficiently. Also, according to the law of priority its first name was *Mya complanata* (Portland Catalogue, 1786, p. 100).

The synonymy for this mussel is very extensive. Simpson (1914, p. 651)

lists six complete pages of different names which have been associated with the species. *Mya complanata* was first used by Solander in an unpublished and undated manuscript. However *Mya* refers to a salt-water species. Dillwyn (1817) recognized Solander's unpublished article but used the name *Unio complanatus* in his catalogue; therefore, the official name, *Elliptio complanatus* (Dillwyn) 1817, is now recognized by most authorities.

The type locality listed by Simpson (1914), and by Ortmann and Walker (1922) is Maryland and New Jersey. As it is one of the most widely distributed mussels, there is extreme variation in its physical characteristics, especially in the shell. As a result, different attempts have been made to separate the species into several subgroups. Lea and several other American conchologists once decided simultaneously to combine all forms found north of Washington, D. C. under the name *Elliptio complanatus*. South of that location they began to apply specific names to the varieties. The diversity of these mussels was so great that eventually they had applied names to a large number of so-called varieties and still could see no relief from the task, as each new lot continued to show differences. The most recent concensus of opinion is that there probably is a typical *Elliptio complanatus* and that, because of genetic variations, one must also include the various intergrades from Florida to the west end of Lake Superior in the same group. One observation to be emphasized is that this genus contains probably more variations in shell characteristics than any other unionid (Matteson, 1948).

For clarity's sake the shell characteristics of a typical specimen as described by Simpson (1914) are listed below:

> Shell generally rhomboid, inequilateral, subsolid to solid, convex; anterior end rounded; dorsal and basal lines nearly or quite parallel; dorsal slope obliquely truncated; posterior ridge well developed, single or double, ending behind at or near the base in a point or biangulation; beaks not much raised nor inflated, their sculpture consisting of strong ridges, which run nearly parallel with the growth lines and are carried back to the nucleus behind as delicate, radial lirae; surface with irregular growth lines, often nearly smooth in young or well developed shells, rough in old ones; epidermis tawny-green to greenish-brown, often rayed and rather smooth in young shells, becoming rough and dark in old ones; left valve with two ragged pseudocardinals and two nearly straight laterals; right valve with one pseudocardinal and often a small one above it with one lateral; beak cavities shallow; muscle scars large, impressed; nacre white, straw color, salmon or various shades of purple.
>
> Length 105, height 55, diam. 33 mm.
> Length 90, height 53, diam. 30 mm.
> Length 60, height 33, diam. 21 mm.
> Length 62, height 40, diam. 25 mm.

Baker (1928) also lists a similar description.

This mussel, which originated in Georgia or Alabama, gradually extended its range northward, east of the Appalachian Mountains. With the advent of the glacial epoch, the northernmost boundaries of its range were pushed southward. As the ice sheet receded, it returned as far north as Cape Breton Island. At the time when Lake Erie, as it is known today, was non-existent, this mussel was able to migrate up the Mohawk River valley to Lake Ontario

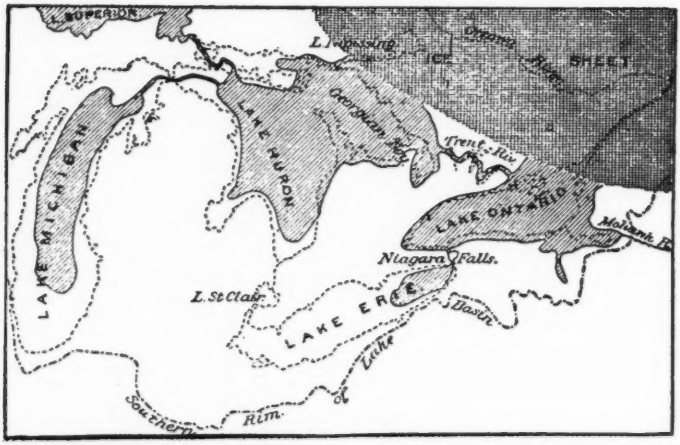


Fig. 14.—Great Lakes region at close of glacial epoch (after Walker).

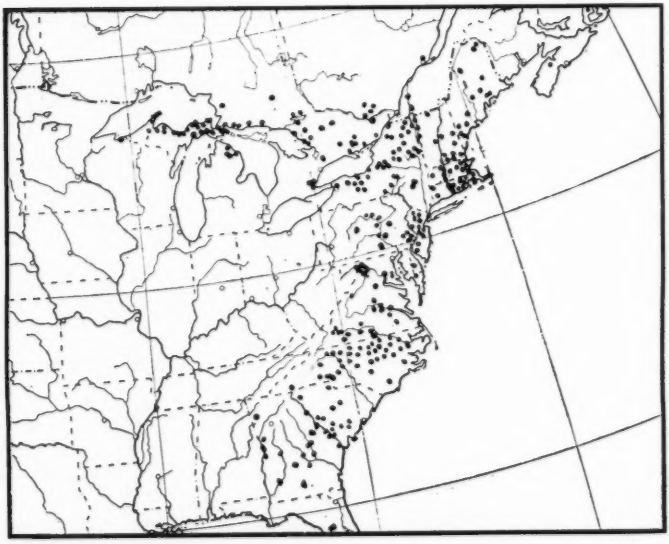


Fig. 15.—Distribution of *Elliptio complanatus*.

(Fig. 14). From there it proceeded through the now extinct Trent River to present day Georgian Bay. It then proceeded westward into Lake Superior (Walker, 1898). As has been mentioned before, the Ocqueoc River drainage system of the Lower Peninsula of Michigan, possesses it (Fig. 16,O.R.). Its distribution today, as plotted from records located in the Division of Mollusks, Museum of Zoology, of the University of Michigan, is limited to the St. Lawrence River, Lake Ontario, Georgian Bay, Ocqueoc River drainage system, the north shore of Lakes Huron and Michigan, Lake Superior and the Atlantic seaboard from Cape Breton Island to northern Florida (Fig. 15).

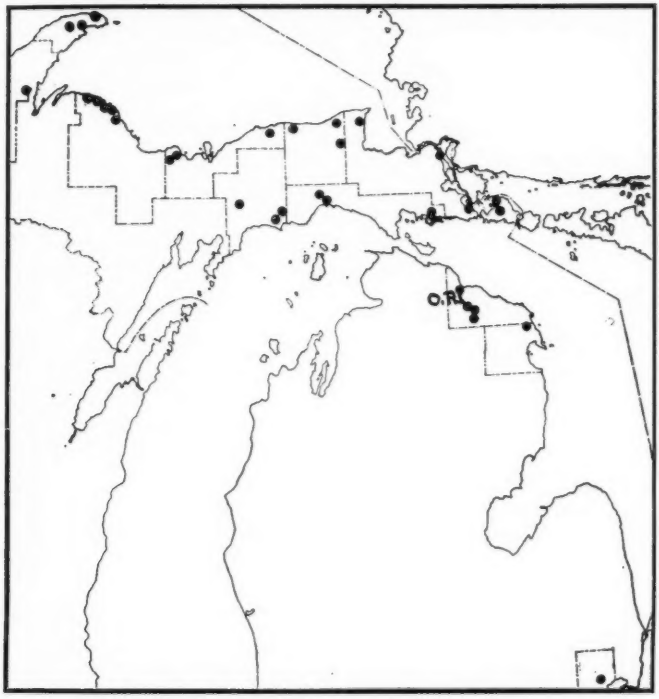


Fig. 16.—Distribution of *Elliptio complanatus* in Michigan.

SUMMARY

1. The fact that mussels are quite dormant during the winter facilitated the establishment, under natural conditions, of a depot containing an ample winter supply.

2. Identification of individual experimental mussels was accomplished by filing a code symbol into the valves.

3. It was found that, if kept for considerable period of time in tubs, *Elliptio complanatus* fared better when the water was unchanged than when a constant supply of warmer lake water was flowing over them.

4. Glass aquaria were most practical for use in parasitizing the fish hosts and maintaining them after infection. The young mussels were most easily obtained from very clean aquaria.

5. Heidenhain's iron-hematoxylin proved to be most satisfactory for staining the tissues in which are represented the various stages of gametogenesis.

6. The ovarian acini contain comparatively few full-sized primary oöcytes in May, shortly after fertilization; but the number increases steadily until late fall when the maximum number is attained. These are stored until they are passed to the suprabranchial chambers in the following late April and May. The primary oöcytes require the penetration of spermatozoa for further development.

7. Spermatozoa are present in the male gonads at all times. However, the acini also contain germ cells in the earlier gametogenetic stages which follow the last reproductive period. As this period again approaches, the number of spermatozoa increases. The sperm ducts are almost devoid of spermatozoa in November, but are full in April and early May.

8. Fertilization occurs normally from late April to late May. This process takes place mainly in the suprabranchial chambers, but may occur in the upper limits of the ovarian ducts, or in the water tubes of the marsupial gills, or in both places.

9. In *Elliptio complanatus* the outer gills act as marsupia. The water tubes of the inner gills open into the mantle cavity, which prevents them from acting as marsupia.

10. The time required for development from the zygote to the glochidium is approximately one month, at least in the area where the study was made. Glochidia are shed normally from the middle of June to the middle of July. Environmental factors, chiefly temperature, are very important in determining the time of shedding.

11. Rough handling and sudden changes of temperature are the chief causes of abortion of ovisacs.

12. The glochidia are hookless and do not possess a byssus, but are often

suspended from a web-like mass of mucous secreted by the female clam.

13. The glochidial attachment of *Elliptio complanatus* is made on the gill filaments of the fish host.

14. The only one of the 12 species of fish, used in the experiments, which successfully harbored the glochidia of this mussel throughout its parasitic stage was the yellow perch (*Perca flavescens*). However, other fish possibly may act as suitable hosts in other portions of the range, or under other conditions.

15. The average duration of the parasitic stage is eighteen days.

16. Parasitism of the fish host is best accomplished in the laboratory by artificial means. The glochidia are relatively hardy and may be refrigerated until they are used.

17. Insufficient data were obtained to permit a conclusive statement concerned with the number of glochidia which would be lethal to the fish host. It was demonstrated, however, that a perch, 6 inches in length, showed no evidence of unfavorable effects from an infection of approximately 500 glochidia.

18. Death of the fish was prevented satisfactorily by lowering the water temperature to approximately 18°C.

19. The advantage of the parasitic stage does not lie only in the availability of a suitable food supply but in protection while metamorphosis of the glochidium occurs.

20. The immature *Elliptio complanatus*, upon leaving the fish, is shaped externally like the glochidium. At the time when the glochidium drops from the fish, no growth has been added to the valves. Subsequently shell material is added rapidly.

21. At the time of dropping, the foot is ciliated only on the tip, which is bilobate and adhesive.

22. The food of the young clam probably is composed chiefly of bacteria, detritus, very small protozoans, and, perhaps, dissolved organic materials.

23. *Elliptio complanatus* does not exhibit sexual dimorphism. Out of 150 adults examined microscopically, one hermaphroditic individual was discovered, with ovarian tissue predominating.

24. Either lakes or large slow-moving streams are suitable habitats for this mussel.

25. When occurring in the same body of water with *Lampsilis siliquoidea, Anodonta grandis,* and *Ligumia nasuta, Elliptio complanatus* is found in a zone beyond these three species and in deeper water. It prefers a substratum composed chiefly of a mixture of clay and sand. It does not thrive on a muddy bottom.

26. Wave action is an important factor in preventing this mussel from occupying a shelf.

27. Physico-chemical analyses of the affected waters were limited to those factors which were thought to influence *Elliptio complanatus* most directly. These factors are temperature, pH, free carbon dioxide, dissolved oxygen, carbonates, bicarbonates and conductivity.

28. Because of its hardiness, the mussel has a very wide distribution. Certain morphological features of the shell are gradually changing, with the result that there is considerable variation in different parts of the range. Some authorities have attempted to establish definite sub-species for this mussel, but at present these are taxonomically unsound.

REFERENCES

ALLEN, WILLIAM RAY 1914—The Food and Feeding Habits of Freshwater Mussels. Biol. Bull. 27: 127-139.

———1921—Studies of the Biology of Freshwater Mussels. Part I. Experimental Studies of the Food Relationship of Certain Unionidae. Ibid. 40: 210-241.

AREY, LESLIE B. 1932—The Formation and Structure of the Glochidial Cyst. Ibid. 62: 212-221.

BAKER, FRANK C. 1898—The Mollusca of the Chicago Area. The Pelecypoda. Bull. Chi. Acad. Sci., 3, Pt. 1: 1-110.

———1916—The Relation of Mollusks to Fish in Oneida Lake. Bull. N. Y. St. Coll. For., Tech. Pub. 4, 1-366.

———1918—The Productivity of Invertebrate Fish Food on the Bottom of Oneida Lake with Special Reference to Mollusks. Ibid. Tech. Pub. 9, 1-264.

———1928—The Fresh-water Mollusca of Wisconsin. Pt. II. Pelecypoda. Bull. Wis. Geol. Nat. Hist. Sur., No. 70: 1-485.

CHURCHILL, E. P. AND SARA I. LEWIS 1924—Food and Feeding in Fresh-water Mussels. Bull. U. S. Bur. Fish., 39: 439-471.

COKER, ROBERT E.—Fresh-water Mussels and Mussel Industries of the United States. Ibid. 36: 13-89.

———, A. F. SHIRA, H. W. CLARK, AND A. D. HOWARD 1921—Natural History and Propagation of Fresh-water Mussels. Ibid. 37: 77-181.

CONNER, CHARLES H. 1907—The Gravid Periods of Unio. Naut., 21: 87-89.

DILLWYN, LEWIS WESTON—1817—A Descriptive Catalogue of Recent Shells, Arranged According to the Linnaen Method. John and Arthur Arch, Pub., Cornhill, London, 1: 1-580.

EGGLETON, FRANK E. 1931—A Limnological Study of the Profundal Bottom Fauna of Certain Fresh-water Lakes. Ecol. Mon., 1: 231-331.

HOWARD, ARTHUR DAY 1915—Some Exceptional Cases of Breeding among the Unionidae. Naut. 29: 4-11.

———1922—Experiments in the Culture of Fresh-water Mussels. Bull. U. S. Bur. Fish., 38: 63-89.

ISLEY, FREDERICK B. 1914—Experimental Study of the Growth and Migration of Fresh-water Mussels. Appendix III, Rep. U. S. Comm. Fish.: 1-24.

LEA, ISAAC 1864—Observations on the Genus *Unio*, together with Descriptions of New Genera and Species. Trans. Amer. Phil. Soc. and Jour. Acad. Nat. Sci., Phil.

LEFEVRE, GEORGE, AND W. C. CURTIS 1910—Reproduction and Parasitism in the Unionidae. Jour. Exper. Zool., 9: 79-115.

LILLIE, FRANK R. 1895—The Embryology of the Unionidae. Jour. Morph., 10: 1-100.

———1897—On the Origin of the Centers of the First Cleavage Spindle in Unio. Sci., 5: 114.

———1898—Centrosome and Sphere in the Egg of Unio. Zool. Bull., 1: 265-274.

MATTESON, MAX R. 1948—The Taxonomic and Distributional History of the Fresh-Water Mussel *Elliptio complanatus* (Dillwyn, 1817). Naut., 61: 127-132; 62: 13-17.

MOFFETT, JAMES W. 1943—A Limnological Investigation of the Dynamics of a Sandy Wave-swept Shoal in Douglas Lake, Michigan. Trans. Amer. Micr. Soc., 62: 1-23.

MURPHY, GARTH 1942—Relation of the Fresh-water Mussel to Trout in the Truckee River. Calif. Fish Game, 28: 89-102.

ORTMANN, ARNOLD *E.* 1911—A Monograph of the Najades of Pennsylvania. Mem. Carn. Mus., 4: 279-347.

——— AND BRYANT WALKER 1922—On the Nomenclature of Certain North American Naiades. Occas. Pap. Mus. Zool., Univ. Mich., No. 112: 1-75.

SIMPSON, CHARLES T. 1914—A Descriptive Catalogue of the Naiades or Pearly Fresh-water Mussels. Bryant Walker, Pub., Ann Arbor Press: 1-1540.

TUCKER, MARY *E.* 1927—Morphology of the Glochidium and Juvenile of the Mussel *Anodonta imbecillis*. Trans. Amer. Micr. Soc., 46: 286-293.

WALKER, BRYANT 1898—The Distribution of the Unionidae in Michigan. Read before Mich. Acad. Sci., (printed by author): 1-23.

———1918—A Synopsis of the Classification of the Fresh-water Mollusca of North America, North of Mexico, and a Catalogue of the More Recently Described Species, with Notes. Misc. Publ. Mus. Zool., Univ. Mich., No. 6: 1-2-3.

Principal Institutional Herbaria of the United States

George Neville Jones and Edna Meadows

Department of Botany, University of Illinois, Urbana

Introduction

Collections of preserved plants, or herbaria, have been maintained for study since the time of the medieval herbalists. The earliest of these collections dates from about the year 1550. At the present time, most of the really great herbaria are in the Old World. Among the largest and most important are the Royal Botanic Garden, Kew, England, founded in 1841 by Sir William Jackson Hooker; the herbarium of the British Museum; the herbarium of the Botanic Garden of the Academy of Sciences of the U.S.S.R.,[1] founded in 1713 by Peter the Great; the Conservatoire et Jardin Botaniques de Geneve, established in 1817 by A. P. DeCandolle; and the Jardin des Plantes, Paris, founded in 1635 by Jean Heroud. Each of these herbaria contains from three to five million specimens.[2] The Botanischer Museum und Garten at Berlin-Dahlem, Germany, formerly one of the greatest herbaria, with about four million specimens, was badly damaged during the war and most of the collection destroyed, but the latest estimate is that approximately 400,000 specimens, including ferns and some fungi, and the Willdenow herbarium, have been saved or acquired subsequently.[3,4]

Other important foreign herbaria, each with more than one million specimens, are the National Herbarium of Melbourne, Australia; Royal Botanic Garden, Edinburgh, Scotland; Uppsala Universitets Botaniska Tradgard, in Sweden; the Botanischer Garten der Universitat, Zurich, Switzerland, founded in 1834 by Oswald Heer; the Jardin Botanique de l'etat, Brussels, Belgium, founded in 1870 by Francois Crepin; and the Botanischer Garten und Botanisches Institut der Universitat, Vienna.

On a basis of comparison with the herbaria of the world the position of the United States is not altogether unfavorable, although for Australia, for example, a country of about the same area, with a population of only six per cent of that of the United States, Blake and Atwood[5] have reported that all the principal subdivisions of Australasia are provided with comparatively modern lists or descriptive floras, and that the "flora as a whole can be

1 Present title: V. L. Komarov Botanical Institute of the Academy of Sciences of U.S.S.R.

2 Gager, C. Stuart, Botanic gardens of the world (second edition). Brooklyn Bot. Gard. Record 27: 151-406. 1938.

3 Alston, A. H. G. Report on the state of taxonomic botany and botanical collections in some areas of Germany since 1939. British Intelligence Objectives Sub-Committee. Report 1520, Item 22. 191 pp. (Mimeographed). London, 1946.

4 Babcock, E. B., Science 107: 622 (June, 1948).

5 Blake, S. F., & Atwood, Alice C. Geographical Guide to the Floras of the World. Part 1. United States Department of Agriculture Miscellaneous Publication No. 401. 336 pp. 1942.

regarded as more satisfactorily covered by published works than that of any equally extensive division of the earth's surface except Europe." In addition to the herbarium at Melbourne, there are large and important herbaria at Sydney, Brisbane, Adelaide, and Perth, and lately a national herbarium has been established at Canberra. There are noteworthy herbaria at Wellington, Auckland, and Christchurch in New Zealand. In South Africa there are great herbaria at Cape Town and Pretoria. In Asia there are important herbaria at Buitenzorg, Singapore, and Calcutta; there are the large Chinese herbaria at Canton (Lingnan University and Sunyatsen University), and others at Nanking, Peking, Kuling, Chengtu, etc., all established since about 1915. The herbarium at Manila, with more than 300,000 sheets of specimens was destroyed during the war. Mention should be made of the rapid growth of herbaria in South America, with active centers of botanical investigation in Rio de Janeiro, Buenos Aires, Tucuman, La Plata, Bogota, and other places. Some of these South American herbaria are as active in research and publication, or more so, than some of the larger herbaria in the United States.

It is the purpose of the present paper, however, to present in concise form some information about the principal institutional herbaria in this country. Private herbaria are not included. No attempt has been made to list herbaria of national parks, forestry offices, etc., unless specimens from such institutions have been cited in monographs or other botanical literature. Questionnaires requesting information as to the official title of the herbarium, its address, the name of the curator and that of the founder, the date of founding, number of specimens, and any special attributes of the collection, were sent to the custodians of the principal herbaria of the United States. Approximately one hundred sixty replies have been received. As was expected, some of them contained complete answers, with interesting comments, while others gave only meager information. Because of this uneven supply of data it has been practicable to incorporate only a very few items of special information into this report. Some herbaria with small or otherwise relatively unimportant collections responded with detailed information, while some others with notable collections supplied little or none. Generally, the more important the collection the less the curator emphasized its contents.

The information contained in this paper is presented under the following topical headings: 1) a list of herbaria of the United States arranged according to age, 2) according to number of specimens, and 3) an alphabetical list of herbaria according to location, giving title, number of specimens, name of curator, director or other custodian, name of the founder, and date of origin of the herbarium.[6] In view of the fact that professional titles were omitted from many of the replies, it has been decided, for the sake of uniformity, to omit all of them from this report. Following the name of the herbarium is the standard abbreviation as given in the lists by J. Lanjouw.[7] Unless other-

[6] For additional information on North American herbaria, and collectors, see F. W. Pennell, pp. 597-628, The Scrophulariaceae of Eastern Temperate North America. Monograph I., The Academy of Natural Sciences of Philadelphia, 1935.

[7] Lanjouw, J. On the standardization of herbarium abbreviations, Chronica Botanica 5: 142-150 (1939); op. cit. 6: 377-378 (1941).

wise indicated the date when this information was assembled is about January 1, 1948.

The fact that there are nearly twenty-three million accessioned specimens in the institutional herbaria of this country would seem to indicate that the time may be ripe for the preparation of a manual of vascular plants of the United States, at least along the lines of a "generic flora" of the type suggested by F. Verdoorn.[8] There is clearly a greater need than ever before for trained botanical systematists in our scientific institutions to continue taxonomic studies of this rich accumulation of botanical material.

One of the conclusions that might be drawn from this brief survey of institutional herbaria in the United States is that almost without exception no first-class university has a second-class herbarium, although there may be a few universities that have no herbarium at all, or even any separate department of botany. Nearly all such exceptional institutions have, however, some sort of reciprocal arrangement with a botanical garden or museum. Likewise, there seems to be a very close connection between development and utilization of the herbarium and the vigor and prestige of a botanical department. This is, of course, precisely what one, especially a botanist, would expect, although it is a conclusion that might tend to be overlooked in these days of rapid development of scientific studies.

During the last half century the following herbaria have been partly or wholly destroyed by fire: California Academy of Sciences, and University of Idaho in 1906; Earlham College, 1924; Clemson College, 1925; University of Tennessee, 1934; more recently, the herbarium of Tuskegee Institute, and in November, 1948, the herbarium of the University of Kentucky.

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Lists of Herbaria

1. CHRONOLOGICAL LIST

Table I is a chronological list of institutional herbaria for which the requisite information is available, arranged according to their date of origin. This table shows the Academy of Natural Sciences of Philadelphia to contain the oldest institutional herbarium in the United States. It was founded in 1812. By the end of 1860 there were only ten institutional herbaria in the entire country. Toward the close of the nineteenth century this number had increased to sixty-four. Perhaps one of the most notable facts shown in this table is the great increase in the number of herbaria during the last fifty years. Sixty-eight new institutional herbaria have been founded in the United States during the twentieth century, or an average of more than one each year. This is obviously correlated with the fact that the first half of the present century

8 Verdoorn, F. The Modern Arboretum, 15 pp. Chronica Botanica Co., Waltham, Massachusetts. 1948.

has produced the greatest activity in plant systematics in the history of the United States. In fact, several important and fair-sized American herbaria are less than twenty years old, as, for example, the herbaria of Duke University (119,890 specimens) and the Catholic University of America (130,000 specimens) were organized only 18 years ago, and that of the Texas A. & M. College (150,000 specimens) is only twelve years old. While there is apparently little or no "age and size" correlation among American herbaria, yet the fact remains that the six institutions reporting one million or more specimens were all founded during the last century.

TABLE I.—Chronological list of herbaria

A. Herbaria founded before 1860

1812 Acad. Nat. Sci. (Phila.)
1829 Amherst College
1830 Bost. Soc. Nat. History
1838 University of Michigan
1850 Charleston (S.C.) Museum
1852 Milwaukee Public Museum
1853 Calif. Acad. Sciences
1856 University of Missouri
1857 Missouri Bot. Garden
1860 College of Pharm. of N. Y.

B. Herbaria founded between 1861 and 1898

1862 Buffalo Soc. Nat. History (N.Y.)
1864 Chicago Acad. Sciences
Gray Herbarium (Mass.)
1865 Michigan State College
1867 New York State Museum
Davenport Publ. Museum (Iowa)
Univ. of Massachusetts
Mycol. Coll. Bur. Pl. Industry (D.C.)
1868 United States Nat. Herbarium (D.C.)
1869 Louisiana State University
University of Illinois
1870 University of Kansas
University of Vermont
Ill. State Normal Univ.
Iowa State College
1871 Knox College (Ill.)
Cornell University (N.Y.)
1872 University of California
Pennsylvania State College
1874 Farlow Herbarium (Mass.)
San Diego Soc. Nat. Hist. (Cal.)
1875 State Teachers Coll. (N.J.)
University of Arkansas
1876 Univ. of New Hampshire
1878 Arnold Arboretum (Mass.)
Grinnell College (Iowa)
Wellesley College (Mass.)
Brown University (R.I.)
1879 Wabash College (Ind.)
1880 Southern Ill. University
University of Washington
Smith College (Mass.)
Kansas State College
Dartmouth College (N.H.)
Haverford College (Pa.)
University of Wisconsin
1881 University of Colorado
1885 Indiana University
University of Nebraska
1888 Oregon State College
University of Tennessee
1889 B. P. Bishop Museum (Hawaii)
Oberlin College (Ohio)
West Virginia University
1890 Purdue University (Ind.)
DePauw University (Ind.)
Eastern Illinois State Coll.
Rhode Island State College
University of Maine
State College of Washington
University of Minnesota
1891 Dudley Herbarium (Cal.)
Soc. Nat. Hist. Delaware
North Dakota Agr. Coll.
1893 Chicago Nat. Hist. Mus.
Montana State College
1895 Carnegie Museum (Pa.)
Yale University (Conn.)
Tulane University (La.)
1896 New York Botanical Garden
Philadelphia College of Pharmacy
New England Botanical Club (Mass.)
1897 University of Wyoming
1898 Ames Orchid Herbarium (Mass.)
Ohio State University

C. Herbaria founded during the present century

1900 Syracuse University (N.Y.)
University of Arizona
Yale School of Forestry (Conn.)
1901 Brigham Young University (Utah)
University of Maryland
Springfield Mus. Nat. History (Mass.)
1902 University of North Carolina
Univ. Fla. Agr. Exp. Sta.
1904 Greene-Nieuwland Herbarium (Ind.)
1905 Baylor University (Tex.)
1906 University of Idaho
Colorado A. & M. College
1908 Pomona College (Cal.)
Western Michigan College
1909 Willamette University (Ore.)
Montana State University
1910 N. Carolina State College
University of South Dakota
Brooklyn Botanic Garden (N.Y.)
Coe College (Iowa)
Economic Herbarium of Oakes Ames (Mass.)
1913 University of Miami (Fla.)
1914 St. Ambrose College (Iowa)
University of Cincinnati
1915 Wayne University (Mich.)
University of Connecticut
1916 Oklahoma A. & M. College
1919 Butler University (Ind.)
1920 University of Oklahoma
Principia College (Ill.)
North Texas State Teachers College
1921 Kent State University (Ohio)
Carleton College (Minn.)
1922 University of Southern California
Morton Arboretum (Ill.)
1923 Mass. Coll. of Pharmacy
St. Bernard College (Ala.)
Santa Rosa Junior College
University of Virginia
1924 University of Georgia
1925 Univ. Calif. Los Angeles
James Millikin Univ. (Ill.)
University of Nevada
U. S. Field Station (Ariz.)
Santa Barbara Museum
Clemson College (S.C.)
1927 Los Angeles County Museum
Grand Canyon National Park
Museum of Northern Arizona
University of New Mexico
1928 Blackland Exp. Station (Texas)
Rancho Santa Ana (Calif.)
1929 Carnegie Inst. Wash. Stanf. Univ. (Cal.)
1930 University of Utah
Duke University (N.C.)
Catholic University (D.C.)
Idaho State College
1931 Utah State Agr. College
Our Lady of the Lake College (Tex.)
Peoria Acad. Science (Ill.)
1933 State Teachers College (Va.)
1934 Univ. Virginia Biol. Station
1935 Texas A. & M. College
Cranbrook Institute (Mich.)
Univ. Minnesota (Duluth)
1938 Illinois State Museum
Virginia State College
Mississippi College
1944 Texas Research Foundation
Southern Methodist University (Tex.)
1948 Am. Acad. Allergy (Ill.)

2. List of Herbaria According to Size

Table II lists the institutional herbaria of the United States according to the number of specimens they contain. Only mounted or otherwise properly accessioned specimens are included in the totals. Unmounted specimens, or specimens in storage awaiting accessioning, are not included. In many herbaria, especially the larger ones, there may be large quantities of such material on hand.

It should be emphasized that the number of specimens attributed to most herbaria are *estimates*, and are not to be considered as exact. Very few herbaria have kept concise records, although a few institutions in this country are exceptional in this respect. For example, the figures for the New York Botanical Garden, the United States National Herbarium, the herbaria of the University of California, University of Michigan, University of Wyoming, University of North Carolina, New England Botanical Club, and a few others,

can be taken as being nearly exact counts, but for nearly all the other herbaria, the figures are merely estimates, and for some are admittedly only guesses.

If the several separate herbaria connected with Harvard University (e.g., Gray Herbarium, Farlow Herbarium, Arnold Arboretum, New England Botanical Club, and the Orchid Herbarium of Oakes Ames) were included as a single institution the total number of specimens would be more than three million, by far the largest collection in the western hemisphere, and equivalent in size and richness of material with some of the European herbaria.

TABLE II.—Herbaria arranged according to size

1. Herbaria with half a million or more specimens

U. S. National Herbarium (D.C.)	2,250,000	Acad. Nat. Sci. (Phila.)	1,000,000
New York Botanical Garden	2,241,685	Farlow Herbarium (Mass.)	982,171
Missouri Botanical Garden	1,500,000	University of California	864,928
Gray Herbarium (Mass.)	1,325,000	Arnold Arboretum (Mass.)	630,000
Chicago Nat. Hist. Museum	1,246,000	Bureau of Plant Industry (Md.)	500,000

2. Herbaria with one hundred thousand or more, but less than half a million specimens

New York State Museum	430,000	New England Bot. Club (Mass.)	197,708
University of Minnesota	400,000	State College of Wash.	175,000
University of Michigan	390,152	University of Vermont	175,000
California Acad. of Sci.	350,000	Texas A. & M. College	150,000
Stanford University (Cal.)	350,000	Oberlin College (Ohio)	142,000
University of Illinois	307,500	B. P. Bishop Museum (Hawaii)	140,000
Pomona College (Cal.)	302,000	Catholic University (D.C.)	130,000
Carnegie Museum (Pa.)	275,000	University of Arizona	120,000
Greene-Nieuwland Herbarium (Ind.)	275,000	Duke University (N.C.)	119,890
Yale University (Conn.)	273,000	Kansas State College	110,000
University of Wisconsin	270,000	Univ. of North Carolina	110,000
Cornell University	267,812	University of Texas	110,000
Brooklyn Botanical Gard. (N.Y.)	250,000	Oregon State College	102,676
Iowa State College	250,000	DePauw University (Ind.)	100,000
Univ. of Pennsylvania	250,000	Brown University (R.I.)	100,000
Univ. of Nebraska	250,000	Michigan State College	100,000
Univ. of Washington	220,000	University of Oklahoma	100,000
Bailey Hortorium (N.Y.)	212,300	University of Florida	100,000
Univ. of Wyoming	206,873		

3. Herbaria with 50,000 to 92,000 specimens

Wellesley College (Mass.)	91,324	University of Missouri	64,725
Los Angeles County Museum	90,000	State University of Iowa	60,000
Purdue University (Ind.)	87,000	Indiana University	60,000
Amherst College (Mass.)	84,000	Univ. of Cincinnati (Ohio)	58,000
Butler University (Ind.)	82,519	Univ. of Massachusetts	56,200
Utah State Agr. College	82,000	University of Colorado	54,000
Pennsylvania State College	81,000	Dartmouth College	52,000
University of Tennessee	81,000	Idaho State College	50,000
Ohio State University	80,000	Rutgers University (N.J.)	50,000
West Virginia University	80,000	Buffalo Museum of Science (N.Y.)	50,000
Milwaukee Public Museum	80,000	University of Cincinnati	50,000
Univ. of Calif. (Los Angeles)	70,000	Montana State College	50,000
Illinois Nat. Hist. Survey	65,000		
Ames Orchid Herb. (Mass)	65,000		

4. Herbaria with 30,000 to 43,000 specimens

Smith College (Mass.)	43,000	University of Maine	32,612
San Diego Nat. Hist. Museum	42,586	Colorado A. & M. College	31,000
University of Arkansas	40,000	Oklahoma A. & M. College	30,432
Southern Meth. University (Tex.)	40,000	Soc. of Nat. Hist. of Delaware	30,000
Rancho Santa Ana Bot. Gard. (Cal.)	40,000	University of Utah	30,000
Syracuse University (N.Y.)	35,000	Willamette University (Ore.)	30,000
Montana State University	35,000	New York College of Pharmacy	30,000
		North Dakota State Agr. Coll.	30,000

5. Herbaria with 20,000 to 29,000 specimens

University of Kansas	29,000	University of Kentucky	25,000
Illinois State Museum	28,261	University of Nevada	21,000
University of Georgia	26,789	Pennsylvania State Museum	20,000
Santa Barbara Mus. (Calif.)	25,467	Univ. of Southern California	20,761
Brigham Young Univ. (Utah)	25,000	Carnegie Inst. Wash. Stanford Univ. (Cal.)	20,000
Yale School of Forestry (Conn.)	25,000	Univ. of Miami (Fla.)	20,000
Texas Research Foundation	25,000		

6. Herbaria with 10,000 to 17,000 specimens

University of Connecticut	16,663	Albion College (Mich.)	12,000
Wabash College (Ind.)	16,317	Darlington Herbarium (Pa.)	12,000
Louisiana State University	16,000	Penn. State Teachers College	12,000
South Dakota State College	15,000	Carthage College (Ill.)	11,501
University of Idaho	15,000	U. S. Field Sta. (Ariz.)	11,000
Springfield Mus. of Nat. Hist. (Mass.)	15,000	Carleton College (Minn.)	11,000
Univ. of Minnesota (Duluth)	15,000	University of Maryland	10,000
North Carolina State College	15,000	Cranbrook Inst. of Sci. (Mich.)	10,000
Ames Econ. Herb. (Mass.)	14,500	Univ. of North Dakota	10,000
Massachusetts College of Pharmacy	14,500	Southern Illinois Univ.	10,000
Davenport Public Mus. (Iowa)	14,000	Econ. Herb. of Oakes Ames (Mass.)	10,000
Univ. of New Hampshire	13,000	Western Michigan College	10,000
Santa Rosa Junior College	12,500	Morton Arboretum	10,000

7. Herbaria with 5,000 to 9,000 specimens

Tulane University (La.)	9,000	R. I. State Teachers College	5,000
N. Tex. State Teachers Coll.	8,500	Blackland Exp. Sta. (Tex.)	5,000
Chicago Academy of Sciences	7,000	St. Ambrose College (Iowa)	5,000
Peoria Academy of Science (Ill.)	6 571	James Millikin University (Ill.)	5,000
Museum of Northern Arizona	6,500	New Jersey State Teachers Coll.	5,000
Our Lady of the Lake College (Tex.)	5,500	Baylor Univ. (Tex.)	5,000
University of New Mexico	5,100	Grinnell College (Iowa)	5,000
		Univ. of South Dakota	5,000
		Texas Agric. Exp. Sta.	5,000

8. Herbaria with less than 5,000 specimens

Knox College (Ill.)	4.500	University of Alabama	2,000
Ill. State Normal Univ.	4,000	Mississippi College	2,000
St. Bernard College (Ala.)	4,000	Wayne University (Mich.)	1,659
Principia College (Ill.)	4,000	Univ. Virginia Biol. Station	1,550
Haverford College (Pa.)	3,500	Kent State University (Ohio)	1,366
Charleston Museum (S.C.)	3,000	State Teachers Coll. (Va.)	1,200
University of Virginia	3,000	University of South Carolina	1,000
Coe College (Iowa)	2,697	Eastern Ill. State Teachers Coll.	1,000
Grand Can. Nat. Park (Ariz.)	2,481	Virginia State College	500
Clemson College (S.C.)	2.260	Am. Acad. Allergy (Ill.)	500
Vanderbilt University (Tenn.)	2,000		

3. LIST OF HERBARIA BY STATES

This list includes 163 herbaria. Following the official name of the herbarium is the standard abbreviation according to Lanjouw; then a statement of the number of specimens of all kinds of plants reported by the curators. The name of the present curator, custodian, or director is given, as well as that of the founder, with the date of the founding of the herbarium, whenever that is known. As previously noted, the information is as of January 1, 1948.

Herbaria in the territories of Alaska and Puerto Rico are not included in the list. We have received no replies from these places.

ALABAMA

St. Bernard College Herbarium (SB), St. Bernard, 4,000.—Curator: Rev. Michael Morgan.—Founded by Bro. Wolfgang Wolf in 1923.

Mohr Herbarium of Geological Survey of Alabama (ALU), University. 2,000.—Founded by C. T. Mohr and E. A. Smith. Date of founding indefinite, but oldest specimens were collected between 1870 and 1880. Very few accessions since Dr. Mohr's death in 1901.—No curator.

Tuskegee Institute Herbarium, Tuskegee Institute, Ala.—Herbarium recently destroyed by fire.

ARIZONA

University of Arizona Herbarium (ARIZ), Tucson. 120,000.—Curator: F. W. Gould.—Founded by J. J. Thornber about 1900. Consists principally of plants of southwestern U. S., with a good representation of the flora of northern Mexico. The Forrest Shreve collection of about 30,000 specimens has been recently acquired.

Herbarium of the United States Field Station, Sacaton. 11,000.—Curator: R. H. Peebles. Founded in 1925. Limited to plants of Arizona.

Herbarium of the Museum of Northern Arizona, Flagstaff. 6,500.—Curator: Katharine Bartlett.—Founded in 1928. Consists exclusively of plants of northern Arizona.

Grand Canyon National Park Herbarium, Grand Canyon. 2,481.—Curator: L. Schellbach. Founded in 1927 by G. E. Sturdevant. Includes only plants of the national park.

ARKANSAS

University of Arkansas Herbarium, Fayetteville. 40,000.—Curator: D. M. Moore. —Founded by F. L. Harvey in 1875.

CALIFORNIA

Herbarium of University of California (UC), Berkeley, 864,928.—Director: H. L. Mason.—Gift of California Geological Survey in 1872.

California Academy of Sciences Herbarium (CAS), San Francisco. 350,000.—Curator: Alice Eastwood.—Founded by A. Kellogg in 1853. Destroyed in the San Francisco earthquake (1906), except types. Rebuilt under Miss Eastwood's direction since that date. Contains principally Californian and other western North American plants, as well as specimens of exotics cultivated in California. Includes the Praeger Herbarium.

Dudley Herbarium of Stanford University (DS), Stanford. 350,000—Director: I. L. Wiggins.—Founded by W. R. Dudley in 1891.

Herbarium of Pomona College (POM), Claremont. 302,000.—Curator: L. Benson. —Founded by C. F. Baker about 1908. Developed chiefly by P. A. Munz from 1917 to 1944. Contains mostly western North American material, including the herbaria of C. F. Baker, and M. E. Jones, and smaller collections.

Los Angeles County Museum Herbarium (LAM), Los Angeles. 90,000.—Curator: Bonnie C. Templeton.—Founded by W. A. Bryan in 1927.

Herbarium of University of California at Los Angeles (LA), Los Angeles. 70,000. —Curator: C. Epling.—Founded by C. Epling about 1925.

San Diego Society of Natural History Herbarium (SD), Balboa Park, San Diego. 42,586.—Curator: Ethel B. Higgins.—Founded by D. Cleveland in 1874. Until 1930 consisted largely of the private herbaria of Daniel Cleveland, and Mary S. Snyder. Representatives of the flora of San Diego County, California, and some specimens from Arizona and Baja California.

Rancho Santa Ana Botanic Garden Herbarium (RSA), 23831 Esperanza Road, Anaheim. 40,000.—Director: P. A. Munz.—Founded by Susanna Bixby Bryant in 1928. Contains also specimens of seedlings, samples of seeds, wood, and bark, and negatives of plant photographs.

Herbarium of Santa Barbara Museum of Natural History, Santa Barbara. 25,467. —Curator: Joan E. Butner. Founded by R. Hoffman in 1927. Consists principally of specimens collected within a radius of 100 miles of Santa Barbara, including a good representation of the flora of the islands.

Herbarium of the Department of Botany of University of Southern California, University Park, Los Angeles. 20,761.—Curator: L. C. Wheeler. Founded about 1922 by Mrs. Effie Spaulding. Chiefly California spermatophytes.

Herbarium of Carnegie Institution of Washington (CI), Stanford University, Stanford. 20,000.—In charge of D. D. Keck.—Founded by H. M. Hall in 1929. Maintained in collaboration with Dudley Herbarium. "We do not encourage citation of this collection in literature because of its admittedly temporary nature. No exchange."

North Coast Herbarium, Santa Rosa Junior College, Santa Rosa. 12,500.—Curator: M. S. Baker. Founded in 1923 by M. S. Baker. Principally plants of North Bay counties of California.

COLORADO

University of Colorado Herbarium (COLO), University of Colorado, Boulder. 54,000.—Curator: W. A. Weber.—Founded by J. Gardner and I. J. McFarlane.

Colorado A. & M. College Herbarium, Fort Collins. 31,000.—Curator: H. D. Harrington. Founded about 1906 by J. Cassidy, J. H. Cowan, and C. S. Crandall. Chiefly Colorado plants.

CONNECTICUT

Herbarium of Yale University (YU), New Haven. 273,000.—Curator: J. R. Reeder.—Founded by D. C. Eaton in 1895. About seventy per cent of the specimens are bryophytes and thallophytes.

Herbarium of Yale School of Forestry (Y), 205 Prospect Street, New Haven. 25,000.—Curator: R. W. Hess.—Founded in 1900. Chiefly of Central American and South American specimens; principally an adjunct to the collection of 44,000 samples of wood.

Herbarium of the University of Connecticut, Storrs. 16,663.—Curator: G. S. Torrey, who oragnized the herbarium about 1915. Includes chiefly Connecticut plants; about twenty-five per cent fungi, and some bryophytes and algae. The E. H. Eames collection of 20,000 sheets recently received, but not yet accessioned.

DELAWARE

Herbarium of Society of Natural History of Delaware (DEL), Wilmington. 30,000. —Curator: R. R. Tatnall.—Founded by W. M. Canby in 1891.

DISTRICT OF COLUMBIA

United States National Herbarium (US), Smithsonian Institution, Washington. 2,250,000.—Curator: E. P. Killip.—Originated in botanical collections, made by early government exploring expeditions, deposited at the Smithsonian Institution; C. C. Parry appointed first curator in 1868. The U. S. National Herbarium is under the direction of the Department of Botany, established July 31, 1947, and consisting of Division of Phanerogams, Division of Grasses, and Division of Cryptogams.

Langlois Herbarium (LCU), Catholic University, Washington. 130,000.—Curator: H. O'Neill.—Founded by A. B. Langlois, but unorganized until 1930. Specializing in

arctic plants and Cyperaceae. "Probably the largest collection of arctic plants this side of the Atlantic Ocean." . . . "Besides the A. B. Langlois collection from Louisiana (except the cryptogams), the herbarium contains the Dutilly collections from the Canadian arctic, T. Holm's collections from Greenland, the O'Neill collections from Florida, Central America, and the Bahamas, and Tidestrom's collections from the Rocky Mountain states."

FLORIDA

Herbarium of the Agricultural Experiment Station of the University of Florida (FLAS), Gainesville. 100,000.—Botanist: E. West: Acting Curator: Lillian E. Arnold. —Founded by H. H. Hume about 1902. Consists of Florida plants, including exotics; also the Severin Rapp collection of mosses, liverworts, and lichens.

Buswell Herbarium, The University of Miami, Miami.—20,000.—Curator and founder: W. M. Buswell. Founded in 1913. Chiefly plants of Florida.

GEORGIA

Herbarium of University of Georgia (GA), Athens. 26,789.—Curator: W. H. Duncan.—Founded by J. Miller and J. M. Reade in 1924.

IDAHO

Herbarium of Idaho State College (IDS), Pocatello. 50,000.—Curator: R. J. Davis.—Founded by R. J. Davis in 1930.

Herbarium of University of Idaho (ID), Moscow. 15,000.—Curator: F. W. Gail. —Founded by J. M. Aldrich about 1906. (L. F. Henderson herbarium destroyed by fire in 1906.)

ILLINOIS

Herbarium of Chicago Natural History Museum (CM), Chicago. 1,246,000.— Director of Botany: Th. Just.—Curator: P. C. Standley.—Founded by Field Columbian Museum in 1893.

Herbarium of University of Illinois (ILL), Urbana. 307,500.—Curator: G. N. Jones. In charge of mycological collections: L. Shanor.—Founded by T. J. Burrill in 1869.

Herbarium of Illinois State Natural History Survey, Urbana. 65,000.—Curator: L. R. Tehon.—Founded by S. A. Forbes.

Herbarium of Illinois State Museum, Springfield. 28,261.—Curator: G. D. Fuller. —Founded by G. D. Fuller in 1938.

Carthage College Herbarium, Carthage. 11,501.—Curator: Alice L. Kibbe.

Herbarium of the Morton Arboretum, Lisle.—10,000 Curator: E. L. Kammerer. Founded in 1922 by J. Morton. Herbarium consists of specimens of woody plants hardy in the Chicago area, and herbaceous plants growing spontaneously in the Arboretum.

Herbarium of Southern Illinois University, Carbondale. 10,000.—Director: J. W. Allen.—Founded by G. H. French about 1880.

Herbarium of Chicago Academy of Sciences, 2001 N. Clark St., Chicago. 7,000. —Curator: Anna Pedersen Kummer.—Founded by F. Scammon in 1864.

Herbarium of Peoria Academy of Science, 107 Park Place, Peoria Heights. 6,571. —Curator: V. H. Chase.—Founded by V. H. Chase in 1931.

Herbarium of The Principia College of Liberal Arts, Elsah.—4,000.—Curator: G. B. Happ. Founded in 1920 by Mrs. Cora Mautz Beals. Local flora.

A. A. Tyler Collection, James Millikin University, Decatur. 5,000.—Founded by Mrs. A. A. Tyler about 1925.

S. B. Mead Herbarium, Knox College, Galesburg. 4.500.—Curator: A. C. Walton. —Founded by A. Hurd in 1871.

Herbarium of Illinois State Normal University, Normal. 4,000.—Curator: Blanche McAvoy. Founded by Geo. Vasey in 1870.

Herbarium of Eastern Illinois State College, Charleston. 1,000.—Curator: E. L. Stover.—Founded by O. W. Caldwell in 1890.

Herbarium of the American Academy of Allergy, College of Pharmacy, University of Illinois, 808 S. Wood St., Chicago.—500.—Curator: R. F. Voigt. Founded March 3, 1948 by the herbarium committee of the Am. Acad. of Allergy.—Consists of specimens of anemophilous plants and their pollens, and prepared slides.

INDIANA

Greene-Nieuwland Herbarium (ND), University of Notre Dame, Notre Dame. 275,000.—Director: A. L. Delisle.—Founded by Rev. J. A. Nieuwland in 1904.

Herbarium of DePauw University (DPU), Greencastle. 100,000.—Curator: T. G. Yuncker.—Founded by L. M. Underwood about 1890.—Good collections of *Cuscuta*, bryophytes, myxomycetes, and vascular plants.

J. C. Arthur Herbarium, Purdue University (PUR), Lafayette. 87,000.—Curator: G. B. Cummins.—Founded by J. C. Arthur in 1890. Ninety per cent of the specimens are rust fungi, the remainder mostly Indiana phanerogams.

Butler University Herbarium (BUT), Indianapolis. 82,519.—Curator: R. C. Friesner.—Founded by R. C. Friesner in 1919.

Herbarium of Indiana University (IND), Bloomington. 60,000.—Curator: C. B. Heiser.—Founded by J. M. Coulter about 1885. The C. C. Deam herbarium is to be deposited here.

Wabash College Herbarium (WAB), Crawfordsville. 16,317.—Curator: A. R. Bechtel.—Founded by J. M. Coulter in 1879.

Earlham College Herbarium, Richmond. Destroyed by fire in 1924, but a few hundred specimens assembled since then, chiefly by L. J. King.

IOWA

Herbarium of Iowa State College (ISC), Ames. 250,000.—Curator: Ada Hayden.—Founded by C. E. Bessey in 1870.

Department of Botany Herbarium (IA), State University of Iowa, Iowa City. 60,000.—Curator: W. A. Anderson.—Founded by T. H. Macbride.—Contains B. Shimek collection.

Herbarium of Davenport Public Museum, 704 Brady St., Davenport. 14,000.—Curator: L. F. Guldner.—Founded by C. C. Parry about 1867.

Grinnell College Herbarium (GRI), Grinnell. 5,000.—Curator: H. S. Conard.—Founded by M. E. Jones about 1878.

Coe College Herbarium, Coe College, Cedar Rapids.—2,697.—Curator: R. V. Drexler.—Founded in 1910 by B. H. Bailey. Vascular plants of Iowa; R. V. Drexler moss herbarium of about 5,000 specimens housed here.

St. Ambrose College Herbarium, Davenport. 5,000.—Curator: Mary K. Vinje.—Founded by U. A. Hauber in 1914.

KANSAS

Kansas State Herbarium (KSA), Kansas State College, Manhattan. 110,000.—Curator: F. C. Gates.—Founded by W. A. Kellerman about 1880.

University of Kansas Herbarium (KANU), Lawrence. 29,000.—Founded by F. H. Snow in 1870.

KENTUCKY

Herbarium of University of Kentucky (KY), Lexington. 25,000.—Curator: F. T. McFarland. Entire herbarium destroyed by fire, November 12, 1948; see *Science* 108: 639.

LOUISIANA

Herbarium of Louisiana State University (LSU), Baton Rouge. 16,000.—Curator: C. A. Brown.—Founded by Americus Featherman in 1869.

Tulane University Herbarium (NO), New Orleans. 9,000.—Curator: J. Ewan.—Founded by R. S. Cocks about 1895.

MAINE

Herbarium of University of Maine (MAINE), Orono. 32,612.—Founded by F. L. Harvey about 1890.

MARYLAND

Mycological Collections, Bureau of Plant Industry (BPI), Plant Industry Station, Beltsville. 500,000.—Curator: J. A. Stevenson.—Founded about 1867. Includes associated collections, such as the C. G. Lloyd Collection of the Smithsonian Institution.

Experiment Station Herbarium, University of Maryland, College Park. 10,000.—Curator: R. G. Brown.—Founded by J. B. S. Norton about 1901.

MASSACHUSETTS

Gray Herbarium of Harvard University (GH), 79 Garden St., Cambridge. 1,325,000.—Director: R. C. Rollins; Acting Curator: R. C. Foster.—Given to Harvard University by Asa Gray in 1864.

Farlow Herbarium (FH), Harvard University, 20 Divinity Ave., Cambridge. 982,171.—Director: W. L. White.—Founder: W. G. Farlow. Officially taken over by Harvard University as the "Farlow Reference Library and Herbarium of Cryptogamic Botany" after Dr. Farlow's death in 1919. The nucleus of the herbarium has existed since 1874. More than half the specimens are of fungi, the remainder are algae, lichens, hepatics, mosses.

Herbarium of Arnold Arboretum of Harvard University (A), Jamaica Plain. 630,000.—Supervisor of Library and Herbarium: I. M. Johnston.—Founded by C. S. Sargent in 1878. E. D. Merrill director 1935-1946.

Herbarium of New England Botanical Club (NEBC), 79 Garden St., Cambridge. 197,708.—Curator: F. W. Hunnewell.—Founded in 1896.

Herbarium of Wellesley College (WELC), Wellesley. 91,324.—Curator: Grace E. Howard.—Founded by Susan Maria Hallowell in 1878.

Amherst College Herbarium (AC), Amherst. 84,000.—Curator: R. D. Northcraft.—Founded by E. Hitchcock in 1829.

Orchid Herbarium of Oakes Ames, Botanical Museum, Harvard Univeristy, Cambridge. 65,000.—Curator: C. Schweinfurth.—Founded by Oakes Ames in 1898.—Contains numerous types, photographs, and drawings of orchids, as well as slides and dissections of flowers.

Knowlton Herbarium (MASS), University of Massachusetts, Amherst. 56,200.—Curator: Gladys I. Miner.—Founded by W. S. Clark in 1867.

Herbarium of Smith College, Northampton.—43,000.—Acting curator: Sara Bache-Wiig.—Founded about 1880.—Consists of 2,700 specimens of algae, 5,000 fungi, the remainder vascular plants.

Luman Andrews Herbarium of Springfield Museum of Natural History (SPR), 236 State St., Springfield. 15,000.—Director: Grace P. Johnson.—Founded by Luman Andrews in 1901.

Herbarium of Massachusetts College of Pharmacy (MCP), 179 Longwood Ave., Boston. 14,500.—Curator: H. W. Youngken. Founded by H. W. Youngken in 1923. In addition to the general collection this herbarium contains a representative collection of medicinal, aromatic and poisonous plants, and crude drugs.

Economic Herbarium of Oakes Ames, Botanical Museum, Oxford Street, Cambridge, 38. 14,500.—Curator: A. F. Hill.—Founded by Oakes Ames in 1910: Consists of herbarium specimens of economic plants. For detailed account see Chronica Botanica 6: 90-91 (1940).

Boston Society of Natural History Herbarium (BSN), 109 Chestnut St., Boston.—Curators: S. K. Harris and Charlotte Pratt.—Founded by the Society in 1830. Number of specimens not ascertained.

MICHIGAN

University Herbarium, University of Michigan (MICH), Ann Arbor. 390,152. Director: E. B. Mains.—Present herbarium founded by C. H. Kauffman in 1921. "The first collection of plants was apparently received in 1838."

Michigan State College Herbarium (MSC), East Lansing. 100,000.—Curator: C. L. Gilly.—Founded by A. Prentiss about 1865.

Albion College Herbarium, Albion. 12,000.—Curator: W. J. Gilbert.—Founded by G. W. Prescott in 1930. Contains the collections of C. W. Fallass. Original herbarium destroyed by fire about 1920.

Cecil Billington Herbarium (BLH), Cranbrook Institute of Science, Bloomfield Hills. 10,000.—Institute Botanist: S. A. Cain.—Founded in 1935.—Oliver Atkins Farwell private herbarium recently acquired, but not accessioned.

Herbarium of Western Michigan College, Kalamazoo. 10,000.—Curator: L. A. Kenoyer.—Founded by L. H. Harvey in 1908. Local plants and materials used in teaching.

Cecil Billington Herbarium of Wayne University, Detroit. 1,659.—Founded by C. Billington in 1915.

MINNESOTA

Herbarium of University of Minnesota (MIN), Minneapolis. 400,000. Acting Curator: G. B. Ownbey.—Founded by C. MacMillan in 1890.

Herbarium of the University of Minnesota, Duluth Branch, Duluth. 15,000.—Founder and Curator: Olga Lakela. Founded in 1935.

Carleton College Herbarium, Northfield. 11,000.—Curator: H. E. Stork. Founded in 1921. Plants of Minnesota, also some from Central America, and the Andes.

MISSISSIPPI

Herbarium of Mississippi College, Clinton. 2,000.—Curator: Robert Howell.—Founded by C. L. Deevers in 1938. Local flora, including some liverworts.

MISSOURI

Missouri Botanical Garden Herbarium (MO), 2315 Tower Grove Ave., St. Louis. 1,500,000.—Curator: R. E. Woodson.—Founded by Henry Shaw in 1857. (J. M. Greenman, curator emeritus). Contains Bernhardi and Engelmann herbaria, and other important collections; large representation of western North American flora. See Bull. Missouri Bot. Gard. 7: 29-35 (1919).

University of Missouri Herbarium (UMO), Columbia. 64,725.—Curator: R. B. Livingston.—Founded about 1856. Mycological collection contains 28,000 specimens. —Curator: W. E. Maneval.

MONTANA

Montana State Herbarium (MONT), Montana State College, Bozeman. 50,000.—Curator: W. E. Booth.—Founded by W. J. Blankinship in 1893.

Herbarium of Montana State University (MONTU), Missoula. 35,000.—Curator: L. H. Harvey.—Founded by J. E. Kirkwood in 1909.

NEBRASKA

Herbarium of University of Nebraska (NEB), Lincoln. 250,000.—Curator: J. F. Davidson.—Founded by C. E. Bessey about 1885.

NEVADA

Herbarium of University of Nevada, Reno. 21,000.—Curator: W. D. Billings.—Founded by P. A. Lehenbauer in 1925.

NEW HAMPSHIRE

Jesup Herbarium (HNH), Dartmouth College, Hanover. 52,000.—Curator: A. H. Chivers.—Includes collection of F. Blanchard.

University of New Hampshire Herbarium, Durham. 13,000.—Curator: A. R. Hodgdon.—Founded by H. G. Jesup about 1876, when it was known as New Hampshire State College Herbarium, but for the next half century was in storage and contained only about 1500 specimens. Under its present name and curator since 1936.

NEW JERSEY

Chrysler Herbarium (RUT), Rutgers University, New Brunswick. 50,000.—Curator: M. F. Buell.—Original collections by N. L. Britton.

Apgar Herbarium, State Teachers College, Trenton. 5,000.—Curators: Lois Meier Shoemaker and M. B. Shoemaker.—Founded by A. C. Apgar about 1875.

NEW MEXICO

Herbarium of University of New Mexico, Albuquerque. 5,100.—Curator: H. J. Dittmer.—Founded by E. F. Castetter in 1927.

NEW YORK

Herbarium of New York Botanical Garden (NY), Bronx, New York. 2,241,685.—Curator: F. J. Seaver.—Founded by N. L. Britton about 1896, on the basis of the Torrey Herbarium of Columbia University.

Herbarium of New York State Museum (NYS), Albany. 430,000.—Curator: S. J. Smith (Curator 1913-1947: H. D. House).—Founded in 1836, the first curator, C. H. Peck, appointed in 1867.

Wiegand Herbarium of Cornell University (CU), Ithaca. 267,812.—Curator: R. T. Clausen.—Started in 1871 with purchase by Andrew D. White of the Horace Mann collection, later combined with herbarium established by K. M. Wiegand in New York State College of Agriculture in 1913; now known officially by the title given above.

Herbarium of Brooklyn Botanic Garden (BKL), 1000 Washington Avenue, Brooklyn. 250,000.—Acting Curator: H. M. Rusk.—Founded by Brooklyn Botanic Garden in 1910.

Herbarium of Bailey Hortorium of Cornell University (BH), Ithaca. 212,300.—Curator: Ethel Zoe Bailey.—Founded by L. H. Bailey.—Gift to Cornell University in 1935.

Clinton Herbarium of Buffalo Society of Natural Sciences (BUF), Humboldt Park, Buffalo. 50,000.—Curator: C. A. Zenkert.—Founded by G. W. Clinton in 1862.

Herbarium of Department of Plant Sciences (SYR), Syracuse University, Syracuse. 35,000.—Curator: M. E. Faust.—Founded by L. M. Underwood about 1900.

Herbarium of College of Pharmacy, W. 68th St., New York. 30,000.—Founded between 1860 and 1880.—Owing to shortage of space this herbarium is being merged with the collections at the New York Botanical Garden on indefinite loan. Contains portions of W. M. Canby and Alphonso Wood herbaria; also H. H. Rusby South American collections.

NORTH CAROLINA

Duke University Herbarium (DUKE), Durham. 119,890.—Curator: H. J. Oosting.—Founded by H. L. Blomquist in 1930. Herbarium (except hepatics) of the American Bryological Society (L.E. Anderson, curator) housed here.

Herbarium of University of North Carolina (NCU), Chapel Hill. 110,000.—Acting Curator: Pauline M. Longest.—Organized by W. C. Coker in 1902 but in existence as scattered collections at least 20 years earlier. About fifteen per cent consisting of fungi, including many types, not only of species described by W. C. Coker and J. N. Couch, but parts of type-material from other herbaria. The phanerogamous collection includes the herbaria of W. W. Ashe, and T. G. Harbison.

Herbarium of North Carolina State College, Raleigh. 15,000.—Curator: W. B. Fox.—Founded by F. L. Stevens about 1910.

NORTH DAKOTA

North Dakota Agricultural College (NDA), Fargo. 30,000.—Curator: O. A. Stevens.—Founded by C. B. Waldron in 1891.

Herbarium of University of North Dakota, Grand Forks. 10,000.—No curator.

OHIO

Oberlin College Herbarium (OC), Oberlin. 142,000.—Acting Curator: G. T. Jones.—Founded by A. A. Wright in 1889.

Botany Department Herbarium, University of Cincinnati (CINC), Cincinnati. 58,000.—Curator: Margaret Fulford.—Founded by H. M. Benedict and E. Lucy Braun in 1914. The hepaticae of the American Bryological Society housed her on indefinite loan.

Kent State University Herbarium (KE), Kent. 1,366.—Curator: C. H. Hobbs.—Founded about 1921.

Herbarium of the Ohio State University (OS), Columbus.—80,000. No curator. Founded about 1898 by W. A. Kellerman.

OKLAHOMA

Bebb Herbarium of University of Oklahoma (OKL), Norman. 100,000.—Curator: G. J. Goodman.—Founded by R. E. Jeffs in 1920. Officially named Bebb Herbarium in 1942; see article by M. Hopkins in Rhodora 45: 265. 1943. Original herbarium, founded by A. H. Van Vleet in 1899, destroyed by fire.

Oklahoma A. & M. College Herbarium (OKLA), Stillwater. 30,432.—Curator: R. Stratton.—Founded by C. O. Chambers in 1916. Original herbarium founded by J. C. Neal in 1893.

OREGON

Oregon State College Herbarium (OSC), Corvallis. 102,676.—Curator: Helen M. Gilkey.—Founded by E. R. Lake in 1888.

Peck Herbarium of Willamette University (WILLU), Salem. 30,000. Curator: M. E. Peck.—Founded by M. E. Peck in 1909.

Herbarium of the University of Oregon (ORE), Eugene.—Contains the herbarium of Thomas Howell. No further information available.

PENNSYLVANIA

Academy of Natural Sciences of Philadelphia Herbarium (PH), Nineteenth St. and the Parkway, Philadelphia. 1,000,000.—Curator: F. W. Pennell.—Founded in 1812. Contains largest representation in U. S. of early North American collections, the largest American collection of Scrophulariaceae, and the most thoroughly developed local herbarium in U. S., containing 200,000 sheets of plants from southern New Jersey, southeastern Pennsylvania, and adjacent Delaware and Maryland.

Carnegie Museum Herbarium (CM), 4400 Forbes St., Pittsburgh. 275,000.—Curator: L. K. Henry.—Founded by Botanical Society of Western Pennsylvania in 1895.

University of Pennsylvania Herbarium (PENN), Philadelphia. 250,000.—Curator: J. M. Fogg, Jr.—Founded by J. M. Macfarlane after 1892. Includes approximately 100,000 sheets of Pennsylvania plants.

Pennsylvania State College Herbarium (PAC), State College. 81,000.—Curator: F. D. Kern.—Founded by W. A. Buckhout about 1872.

Herbarium of Pennsylvania State Museum (PAS), Harrisburg. 21,500.—Curator: R. Troxel.

Darlington Herbarium, Pennsylvania State Teachers College, West Chester. 12,000.—Curator: R. G. Gordon.—Founded in 1826 by Wm. Darlington. Small but historically valuable collection, including 50-60 Rafinesque specimens (See Bartonia 22: 6-9. 1943).

Haverford College Herbarium, Haverford. 3,500.—Curator: H. K. Henry.—

Founded about 1880. Now deposited in Academy of Natural Sciences of Philadelphia.

Herbarium of Philadelphia College of Pharmacy and Science, Philadelphia. Number of specimens not ascertained.—Curator: T. P. Haas. Started with the gift in 1896 of the I. C. Martindale herbarium, consisting of collections of Martindale, Ferdinand Rugel, and others. (See Am. Journ. Pharmacy 116: 420-432. 1944.)

RHODE ISLAND

Herbarium of Brown University (BRU), Providence. 100,000.—Curator: G. L. Church.—Founded by S. T. Olney in 1878. Mostly North American plants; contains the collections of S. T. Olney, and W. W. Bailey.

Herbarium of Rhode Island State College, Kingston. 5,000.—Curator: E. A. Palmatier. Founded by L. F. Kinney, Sr. in 1890.

SOUTH CAROLINA

Charleston Museum Herbarium (CHARL), Charleston. 3,000.—Director: E. Milby Burton.—Founded by Charleston Museum about 1850. Includes portions of the herbaria of H. W. Ravenel, F. P. Porcher, and others. The Elliott Herbarium is kept in a separate case.

Clemson College Herbarium (CLEMS), Clemson. 2,260.—Founded in 1925. Old herbarium destroyed by fire in 1925.

University of South Carolina Herbarium, Columbia. 1,000.—Founder and date of founding unknown. No curator.

SOUTH DAKOTA

Herbarium of South Dakota State College (SCD), Brookings. 15,000.—Curator: J. Winter.—Founder and date of founding not known.

University Herbarium, University of South Dakota (SDA), Vermillion. 5,000.—Curator: J. Verduin.—Founded by S. S. Visher and W. H. Over in 1910.

TENNESSEE

Tennessee State Herbarium (TENN), University of Tennessee, Knoxville. 81,000.—Curator: A. J. Sharp.—Founded by F. Lamson Scribner in 1888. Destroyed by fire in 1934; present herbarium assembled since that date.

Vanderbilt University Herbarium, Nashville. 2,000.—Curator and founder: Elsie Quarterman.

TEXAS

Tracy Herbarium (TAES), Agricultural and Mechanical College of Texas, College Station. 150,000.—Botanist: H. B. Parks.—Founded in 1935.

University of Texas Herbarium (TEX), Austin. 110,000.—Director: B. C. Tharp. Herbarium started in the early 1890's by F. W. Simonds and continued by W. L. Bray; collection greatly enlarged by pioneer work of Dr. Mary S. Young between 1912 and the year of her death, 1919.

Herbarium of Southern Methodist University, Dallas. 40,000.—Founded by C. L. Lundell in 1944.—Mostly Texas plants.

Lundell Herbarium, Texas Research Foundation, Box 43, Renner. 25,000.—Curator: C. L. Lundell; founded by C. L. Lundell in 1944. Principally southwestern U. S., Mexican and Central American plants. This herbarium was formerly on loan to Southern Methodist University, but was withdrawn in 1948 and set up at the Texas Research Foundation. Contains isotypes and types of most species described by Lundell from Texas, Mexico, and Central America.

Herbarium of North Texas State Teachers College, Denton. 8,500.—Founded by B. B. Harris in 1920. Curator: J. B. McBryde.

Baylor Herbarium, Baylor University, Waco. 5,000.—Curator: Cornelia M. Smith. Founded by Lulu Pace about 1905.

Herbarium of Our Lady of the Lake College (LLC), San Antonio. 5,500.—Curator: Sr. Mary Clare Metz.—Founded in 1931.

Blackland Experiment Station Herbarium (TEXA), Temple. 5,000.—Superintendent: H. O. Hill.—Founded by S. E. Wolf in 1928.

UTAH

Intermountain Herbarium (UTC), Utah State Agricultural College, Logan. 82,000.—Curator: A. H. Holmgren.—Founded by B. Maguire in 1931.

Herbarium of University of Utah (UT), Salt Lake City. 30,000.—Curator: W. P. Cottam.—Founded by W. P. Cottam in 1930.

Brigham Young University Herbarium (BRY), Provo. 25,000.—Curator: B. F. Harrison.—Founded by C. Van Buren in 1901.

VERMONT

Pringle Herbarium of University of Vermont (VT), Burlington. 175,000.—Curator: E. J. Dole.—Founded by C. G. Pringle about 1870.

VIRGINIA

University of Virginia Herbarium (VA), Charlottesville. 3,000.—Founded by I. F. Lewis in 1923.

Mountain Lake Biological Station Herbarium, Mountain Lake. 1,550. Founded by I. F. Lewis in 1934.

Edith Stevens Herbarium, State Teachers College, Farmville. 1,200.—Curator: R. T. Brumfield. Founded about 1933 by Edith Stevens. Plants of Prince Edward, Cumberland, and Buckingham counties.

Herbarium of Virginia State College, Petersburg. 500.—Curator: P. H. Baker. Founded about 1938.

WASHINGTON

University of Washington Herbarium (WTU), Seattle. 220,000.—Curator: C. Leo Hitchcock.—Founded by the Young Naturalists' Society of Seattle about 1880. Brief note in Leafl. West Bot. 1: 198.

Herbarium of State College of Washington (WTC), Pullman. 175,000. Curator: M. Ownbey.—Founded by C. V. Piper about 1890.

WEST VIRGINIA

West Virginia University Herbarium (WVA), Morgantown. 80,000.—Curator: E. L. Core.—Founded by C. F. Millspaugh in 1889.

WISCONSIN

Herbarium of University of Wisconsin (WIS), Madison. 270,000.—Curator: N. C. Fassett.—Founded by W. Trelease and D. Henry about 1880.

Herbarium of Public Museum of the City of Milwaukee (MIL), 818 W. Wisconsin Ave., Milwaukee. 80,000.—Curator: A. M. Fuller.—Founded by Peter Engelmann in 1852.

WYOMING

Rocky Mountain Herbarium (RM), University of Wyoming, Laramie. 206,873.—Curator: C. L. Porter.—Founded by A. Nelson about 1897.—Rich in types, isotypes of western North American plants, including collections of Greene, Rydberg, Payson, and Nelson. Fine collections of *Astragalus*.

HAWAII

Herbarium of Bernice Pauahi Bishop Museum (BISH), 1202 Houghtailing Road, Honolulu. 140,000.—Curator: Marie C. Neal.—Founded by C. R. Bishop in 1889.—The Museum restricts its collections to the Pacific Ocean Area and does not keep plants from the continental areas bordering the Pacific Ocean.

The Vegetation of Sodon Lake

Stanley A. Cain

Cranbrook Institute of Science, Bloomfield Hills, Michigan

John V. Slater*

Detroit, Michigan

In 1947 a program of limnological studies was commenced by the scientific staff of Cranbrook Institute of Science. The season's activities were concentrated largely on Sodon Lake, Sec. 20, Bloomfield Township, Oakland County, Michigan. Sodon Lake is a pond of 5.7 acres lying in the Outer Defiance moraine (Stanley, 1936). It is apparently a kettlehole or ice-block lake surrounded by morainal hills and reaching a maximum depth of slightly less than 60 feet, with about 10 per cent of its area deeper than 50 feet. It has a small inlet bringing surface drainage from a few acres, but it is apparently supplied most of its water by subterranean sources. A small outlet, flowing at wetter seasons, connects to the east with Echo Lake. The original lake, in early postglacial time, covered approximately twice the present area. Whatever the details of its history, preliminary pollen studies indicate that the ice block had melted, the lake formed, and sedimentation commenced before the close of the pre-boreal spruce-fir period of the region, for the marly clays of the deepest sediments sampled (24 feet) contain a dominance of species of the Canadian forest (Cain, 1948; Cain and Cain, 1948).

In the present study the vegetation of Sodon Lake is considered in its broadest aspect, including not only that within the area of open water, but also that occupying the sedimentary soils within the basin of the original lake. Only brief mention is made in this paper of the character of the upland vegetation.

Of minor importance in themselves, these descriptions should play a useful role as background material for the chemical-physical and biological studies of the contemporary pond (Newcombe and Slater, 1948, 1949), and in the interpretation of the history of this body of water and its vegetation as it is being worked out by stratigraphic and pollen analyses (Cain and Slater, 1948).

In the following outline of the communities which we have recognized at Sodon a "polyphase" classification is attempted which combines life-form, ecological, successional, and floristic relationships in the arrangement. These are natural areas of small order (Cain, 1947). Whether certain of them are valid communities is a question which deserves more study. It is certainly impossible to state, only on the basis of the local study, that several of these so-called communities are examples of associations in the sense that they are representative of widespread types of vegetation. In the absence of comparative data from intensive studies over a wide area, or on a regional

* Graduate student, Wayne University.

basis, our naming of these communities (whether in the English or the Latinized form) is tentative and for the sake of convenience of reference. For example, as common and widespread a natural area as the red maple swamp forest is certainly not everywhere the same floristically or ecologically (compare the study by Cain and Penfound, 1938, on the red maple swamp forest on Long Island), although the role in succession and general physiognomy of the different stands may be approximately the same. In some cases the natural areas which we have recognized and named in terms of plant communities are so small and their vegetation so fragmentary that the interpretatior is inevitably based on wider experience than that at Sodon. In any case, we believe in the procedure of working from detailed local considerations of the structure and composition of vegetation to the more abstruse and less important problem of classification.

The conditions seem to indicate that floristic matters should play the primary role in the classification of local communities, with successional, ecological, and physiognomic phenomena playing secondary roles. These secondary relations are both obvious and important in the compressed conditions of a small lake border. If the science of ecology has reached any valid conclusions, one of them is that these different phenomena are part of the same complex of processes and interrelations and that an order produced by the primary consideration of one of them should be in essential harmony with an order produced by one or more of the others, although the classificatory units may at times be more or less broad from one point of view than from another. For example, within the shrub-dominated zone there can occur both floristic and ecological subdivisions, whereas in the deciduous tree-dominated zone there may be floristic differences without obvious ecological difference.

CLASSIFICATION OF THE COMMUNITIES OR NATURAL AREAS OF SODON LAKE

I. Submersed communities
  - A. Plankton communities
    1. Euplankton communities
       - a. Seasonal communities
       - b. Depth or layer communities
    2. Tychoplankton communities
  - B. Macrophytic communities
    1. Fragmentary moss community
    2. Communities of stonewort algae
       - a. Charetum contrariae
       - b. Charetum nitellosum
       - c. Charetum potamogetonosum

II. Emersed and floating-leaved littoral communities
  - A. Spikerush-stonewort community (Eleocharidetum palustris charosum)
  - B. Fragmentary littoral communities
    1. Waterlily community (Nupharo-Nymphaeetum)
    2. Cattail community (Typhetum latifoliae)

III. Herb-dominated marsh or fen communities

A. Herb fen (Dryopteridetum Thelypteridis eleocharosum)
B. Island-like lake margin communities
1. Fern hummocks (Dryopteridetum Thelypteridis)
2. Swamp loosestrife stools (Lythretum Salicariae)

IV. Shrub-dominated marsh communities
A. Shrubby cinquefoil community (Potentilletum fruticosae)
B. Bog birch community (Betuletum pumilae)
Either A and B or C
C. Betuletum pumilae potentillosum

V. Swamp forest communities
A. Tamarack community (Laricetum laricinae)
B. Aceretum rubri laricosum
C. Red maple swamp forest (Aceretum rubri)
D. Aceretum rubri ulmosum
E. Ulmetum americanae
VI. Upland forest communities, not properly a part of this study

THE COMPOSITION AND STRUCTURE OF THE COMMUNITIES

Plankton.—The plankton of Sodon Lake is being studied and will be reported on in one or more separate papers. Ten-liter water samples, obtained by pumping at several stations and depths, and separated into net plankton and nanoplankton, have been taken at regular intervals since late spring of 1947. Further studies of plankton have been going forward simultaneously by means of seeding-on experiments using numerous plastic slides attached to wooden blocks exposed on continuous two-week and six-week cycles at several stations and depths. It is sufficient to state at the present time that there are indications of strong compositional differences in the phytoplankton at different seasons and at different depths in the water. At different seasons such euplanktonic organisms as *Dinobryon sertularia*, Ehr., *Asterionella formosa* Hass., and *Fragillaria* sp. have been especially abundant, and superficial blooms have been formed at one time or another by *Oscillatoria tenuis* var. *natans* Gom., *Coelosphaerium Kuetzingianum* Nag., *Anabena flos-aquae* (Lyngb.) de Breb., *Aphanizomenon flos-aquae* (L.) Ralfs., etc. A chlorobacteriacium, probably *Pelogloea*, occurred in tremendous concentrations through most of the summer at about the top of the hypolimnion. Superficial rafts and clouds of filamentous greens such as species of *Mougeotia*, *Zygnema*, *Zygogonium*, *Ulothrix*, and *Spirogyra* at times covered the tops of the more shallow *Chara* beds or floated near the surface of the water. The bottom, which is a very soft marly muck, has at times had quantities of bluegreens such as *Phormidium tenue* (Menegh.) Gom., *Oscillatoria limosa* Gom., *O. Chalybea* Gom., *O. tenuis* var. *tergestina* Gom. or small balls of *Aphanothece stagnina* (Spreng.) A. Gr., even to depths of 30 feet. The tychoplankton has proven to be moderately rich for a marl lake, and abundant epiphytic forms such as *Oedogonium* have grown on the *Chara*, petioles and blades of waterlilies, etc. No attempt will be made at this time to treat the problem of what constitutes a community under planktonic conditions.

Submerged communities of macrophytic plants.—The aquatic moss, *Dre-*

panocladus fluitans (Hedw.) Warnst., is apparently the only large plant extending to depths below the beds of *Chara* and *Nitella*. The plant grapple sometimes brought up quantities of it from depths of 15 to 20 feet, indicating the formation of beds, and sometimes recovered small amounts of the moss to depths greater than 20 feet. It apparently has a spotty occurrence on the bottom. The water is comparatively opaque; yet the moss grows at greater depths than light is registered by a submarine illuminometer.

Communities of the stonewort algae.—The littoral zone of Sodon Lake is essentially dominated by a single community, the *Charetum contrariae*. The shape of the lake bottom is unusual for a *Chara* lake. There is a shallow shelf, usually 25 to 40 feet wide, which slopes gradually from the shore line to a depth of about three to four feet, where it drops off abruptly to depths of seven or eight feet, below which the slope is more gentle. This "soup plate" form (fig. 1) suggests a previous history as a bog lake, but such apparently has not been the case. The complete shelf, the steep slope, and the deeper levels to about 14 to 15 feet are characteristically dominated by a dense stand of *Chara contraria* (fig. 1). In the shallow water the tips of the *Chara* plants reach the surface; at the drop-off the plants may be two to three feet tall, but do not reach the surface. Here and there the *Chara* bed may be partially interrupted or the marly bottom even exposed. This is often due to the action of nesting fish, but never, apparently, to wave attrition. In fact, nowhere does the shore vegetation or the bottom show evidence of wave attrition. This general community, the dominant one of the lake, occurs over most of the area without associates other than planktonic species. Two variants, however, can be recognized. One is the *Charetum nitellosum* in which *Nitella* is admixed in quantities ranging up to codominance. This variant occurs mainly in the lower portion of the *Chara* zone from 11 to 14 feet. The other variant is the *Charetum potamogetonosum*, in which *Potamogeton foliosus* is admixed. It is confined to the lower parts of the steep shelf slope, being rooted at about seven to nine feet. When mature, it extends to or nearly to the surface of the water, but never occurs in sufficient abundance to reduce the quantity of *Chara*.

Emersed and floating-leaved littoral communities.—Around the edge of

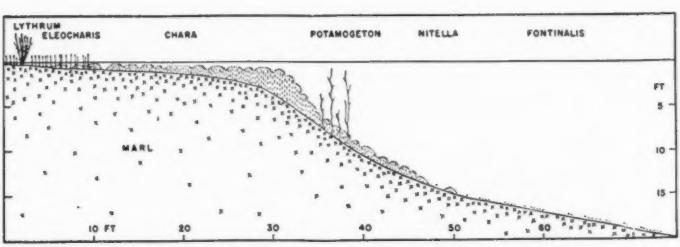

Fig. 1.—Radial profile of a typical part of the lake margin showing the "soup plate" form of the lake bottom.

the lake there is an almost continuous zone in which *Eleocharis palustris* grows up through the *Chara* and is emersed about one foot. The aquatic moss, *Drepanocladus aduncus* (Hedw.) Warnst., is fairly frequent in this zone, and *Zanichellia palustris* var. *major* (Boem.) Koch. is occasional. The combination of these few species, termed the *Eleocharidetum palustris charosum*, grows from the shoreline to depths of 10 to 12 inches. It is in this zone that the island-like communities occur, which will be described shortly. It is also in this zone in which the white waterlilies, *Nymphaea odorata*, occur, some of the patches of the yellow waterlily, *Nuphar variegatum*, and the cattail community. All of the colonies of the white waterlily occur in very shallow water, as do most of the yellow waterlilies, but some patches of the latter occur farther out on the shelf or even at its margin in water up to about seven feet. The two waterlilies do not occur intermixed, but because they occupy in part the same zone and only occur in a few disconnected patches, they are classified together as the *Nupharo-Nymphaeetum*. The cattail stand is fragmentary and not typical of its frequent occurrence elsewhere in the area.

Because of their relative structural simplicity, none of the preceding communities warrants quantitative analysis.

Herb-dominated marsh or fen communities.—In general the contour of the shoreline of Sodon Lake seems regular in sweep, but a closer examination reveals that where the water meets the shore the outline is often somewhat scalloped. This is due to the clumps of *Lythrum Salicaria* and the hummocks of the swamp fern, *Dryopteris Thelypteris* var. *pubescens*. Not only do more or less consolidated patches of these plants compose much of the shoreline, but isolated ones occur like small islands in the *Eleocharidetum palustris charosum*. Here they are semi-floating in the sense that they can be dislodged easily and moved about by hand on the very soft substratum of marly muck. It seems likely that many of these islands have become disconnected and moved into the *Chara* zone by ice action. The two types of islands are quite dissimilar in nature. *Lythrum* forms stools. The numerous wand-like branches arise from a crown and a small dense mat of roots at the surface of the soil and extend about four feet above the water. An abundant aerenchyma, very much alike that of *Decodon verticillatus*, is formed on the stems below the water level. Several species (about 16) are associated with these stools, but none typically has a high frequency or approaches codominance except the associated *Eleocharis palustris*, which occasionally does so in the smaller clumps. The islands of the swamp fern are referred to as hummocks, and their form is radically different from those of *Lythrum*. The fronds of the ferns arise from cylindrical, dome-topped columns composed of peat and a tangle of roots which extend to about six inches above water level. The portion of these hummocks in the air is covered with mosses such as *Calliergonella cuspidata* (Hedw.) Loeske, while that under the water sometimes is surrounded by aquatic mosses. The fern hummocks offer a superior surface for invasion by marsh species so that their total flora is about twice that of the *Lythrum* clumps.

Table 1 gives some sociological data concerning these islands which vary

in size, but average about 1/4 sq. m. each. It did not seem practical to attempt percentage coverage estimates, so each species was merely classified according to whether it was dominant (D), codominant (d), or present in small amount (x). The procedure used in this survey was to go around a portion of the margin of the lake examining each distinct island as it was encountered. A few of them were mixtures of the swamp loosestrife and the fern, but the vast majority were dominated by one or the other species. The mixtures

TABLE 1.—Certain sociological characteristics of the herbaceous "islands" in the zone of *Eleocharis palustris*, Sodon Lake.

	Dryopteridetum Thelypteridis 25 1/4-sq. m. islands		Lythretum Salicariae 25 1/4-sq. m. islands	
	Coverage classes X d D	Frequency %	Coverage classes X d D	Frequency %
Dryopteris Thelypteris var. pubescens	— — 25	100	4 — —	20
Eleocharis palustris	19 — —	76	19 6 —	100
Lycopus americanus var. Longii	19 — —	76	9 — —	36
Boehmeria cylindrica var. Drummondiana	13 — —	52	1 — —	4
Cicuta maculata	12 — —	48	6 — —	24
Hypericum virginicum var. Fraseri	11 — —	44	4 — —	16
Solidago ohioensis	11 — —	44	— — —	—
Lythrum Salicaria	9 1 —	40	— — 25	100
Scutellaria galericulata	9 — —	36	4 — —	16
Glyceria striata	9 — —	36	— — —	—
Carex laxiflora	— 8 —	32	1 — —	4
Ulmus fulva, seedlings	8 — —	32	2 — —	8
Impatiens biflora	7 — —	28	3 — —	12
Rumex Brittanica	5 — —	20	— — —	—
Bromus ciliatus	4 — —	16	— — —	—
Eupatorium maculatum	3 — —	12	1 — —	4
Calamagrostis canadensis	3 — —	12	— — —	—
Asclepias incarnata	3 — —	12	3 — —	12
Urtica procera	3 — —	12	1 — —	4
Cardamine pratensis var. palustris	3 — —	12	— — —	—
Rosa palustris	1 — 1	8	— — —	—
Lathyrus palustris	2 — —	8	1 1 —	8
Galium boreale var. typicum	2 — —	8	— — —	—
Rhus radicans	1 — —	4	— — —	—
Liparis Loesellii	1 — —	4	— — —	—
Cornus stolonifera	1 — —	4	— — —	—
Scirpus validus	1 — —	4	— — —	—
Carex sp. (sterile)	1 — —	4	— — —	—
Solanum Dulcamara	1 — —	4	2 — —	8
Campanula uliginosa	1 — —	4	— — —	—
Typha latifolia	— — —	—	1 — —	4

seemed to be due to the establishment of *Lythrum* in *Dryopteris* hummocks or to ice fragmentation of the consolidated mat. There was little evidence of the invasion of *Lythrum* by *Dryopteris* except in the shallowest water. Table 1 omits the mixed islands and gives the data for 25 stands or islands of each of the two types. The species of the islands also occur in the herb-dominated marsh.

The herbaceous fen, *Dryopteridetum Thelypteridis eleocharosum,* is nowhere extensive, but west of the inlet it occurs in typical form (figs. 2, 3). Its development is obviously a succession from the *Eleocharidetum palustris charosum,* accomplished in part by the consolidation of the previously described islands, especially the fern hummocks. There is a widespread admixture of sedges and grasses, the roots of which help greatly in binding the mat

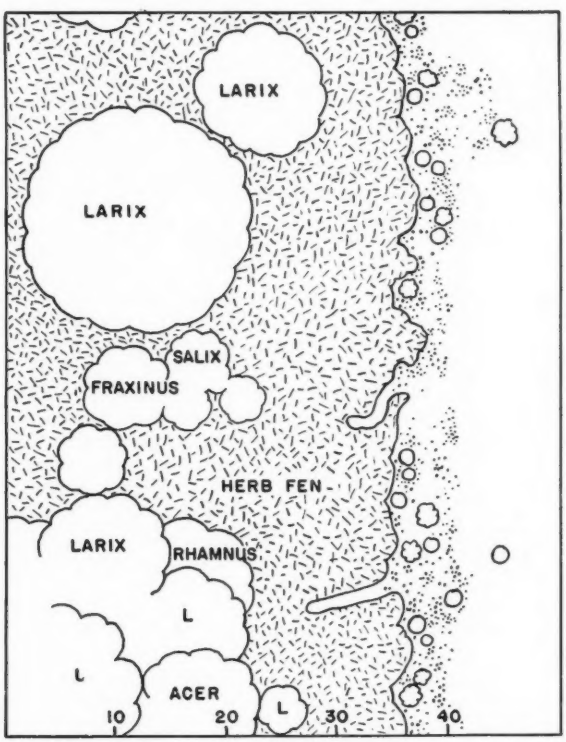

Fig. 2.—Sketch map of lake margin (scale in feet) showing "islands" in the *Eleocharis-Chara* zone, and invasion of the herb fen by trees and shrubs.

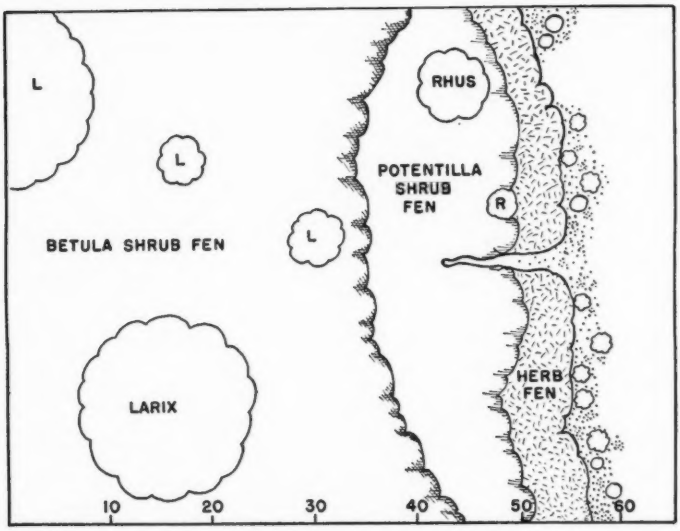

Fig. 3.—Sketch map of lake margin (scale in feet) showing zonation of fen communities on sub-aerial peat.

even where the foliage cover is low. This community is rich in species (table 2*) and includes several plants common in acid bogs although the peaty substratum is circumneutral in reaction. Although the substratum is at all times soggy, its surface is typically about two to four inches above the water table. The herb-dominated marsh is eventually invaded by woody plants. The first invader able to establish a closed cover is characteristically the shrubby cinquefoil, *Potentilla fruticosa*. The bog birch, *Betula pumila*, may come in under the same conditions as the *Potentilla*, but it characteristically becomes dominant where the marsh surface is slightly more elevated above the water table (fig. 3). Being taller, the birch competes successfully with the cinquefoil where the two are mixed. Both *Cornus stolonifera* and *C. racemosa* and four native species of *Salix* occur under the same conditions as the preceding two species, but none is here dominant except for the area of its isolated patches. Due to the small total area occupied by the shrub-dominated marsh which succeeds the herbaceous fen, these two phases may be classified together as the *Betuletum pumilae potentillosum* (table 2). On the other hand, there are marshes in the County where one dominates alone, where the birch definitely succeeds the cinquefoil in competition, and where it does well with a somewhat lower water table. Hence there is equal justification for considering them to be separate communities, as in the preceding outline of

* In this and succeeding tables the coverage classes have the following significance: (x) less than 1%; (1) 1-5%; (2) 6-25%; (3) 26-50% (4) 51-75%; (5) 76-100%.

TABLE 2.—Certain sociological characteristics of the herbaceous and shrubby fen, Sodon Lake.

	Betuletum pumilae potentillosum 15 quadrats 4-sq. m. Coverage classes							Dryopteridetum Thelypteridis eleocharosum 10 quadrats 1-sq. m Coverage classes						
	X	1	2	3	4	5	F-%	X	1	2	3	4	5	F-%
Woody plants														
Potentilla fruticosa	—	—	5	5	5	—	100.0	2	1	—	—	—	—	30
Betula pumila	—	2	6	6	—	—	93.3	—	1	—	—	—	—	10
Cornus racemosa	2	3	2	1	—	—	52.8	—	—	—	—	—	—	—
Rhamnus alnifolia	2	3	2	—	—	—	46.2	2	—	—	—	—	—	20
Ulmus fulva	2	—	—	—	—	—	13.2	—	—	—	—	—	—	—
Rubus strigosus	2	1	—	—	—	—	19.8	—	—	—	—	—	—	—
Cornus stolonifera	—	—	1	—	—	—	6.6	1	—	—	—	—	—	10
Salix Bebbiana	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Salix discolor var. latifolia	2	—	—	—	—	—	13.2	2	—	—	—	—	—	20
Fraxinus lanceolata	4	—	—	—	—	—	26.4	—	—	—	—	—	—	—
Rhus radicans	2	—	—	—	—	—	13.2	—	—	—	—	—	—	—
Rubus triflorus	7	—	—	—	—	—	46.2	—	—	—	—	—	—	—
Viburnum dentatum	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Solanum Dulcamara	2	—	—	—	—	—	13.2	—	—	—	—	—	—	—
Salix candida	2	—	—	—	—	—	13.2	2	1	—	—	—	—	30
Salix serissima	2	—	—	—	—	—	13.2	—	—	—	—	—	—	—
Parthenocissus quinquefolia	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Acer rubrum	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Rhus Vernix	—	1	—	—	—	—	6.6	—	—	—	—	—	—	—
Salix alba var. vitellina	—	1	—	—	—	—	6.6	—	—	—	—	—	—	—
Larix laricina	—	—	—	—	—	—	—	—	1	—	—	—	—	10
Herbaceous plants														
Carex laxiflora	7	8	—	—	—	—	100.0	4	1	—	—	—	—	50
Dryopteris Thelypteris var. pubescens	11	—	—	—	—	—	66.6	—	—	3	5	2	—	100
Pycnanthemum virginianum	7	2	—	—	—	—	59.4	—	—	—	—	—	—	—
Lycopus americanus var. Longii	9	—	—	—	—	—	59.4	8	—	—	—	—	—	80
Bromus ciliatus	7	—	—	—	—	—	46.2	2	—	—	—	—	—	20
Solidago altissima	4	3	—	—	—	—	46.2	1	1	—	—	—	—	20
Eupatorium maculatum	3	3	—	—	—	—	39.6	1	3	—	—	—	—	40
Apocynum cannabium var. glaberrimum	6	—	—	—	—	—	39.6	1	—	—	—	—	—	10
Vernonia sp.	5	1	—	—	—	—	39.6	—	—	—	—	—	—	—
Cirsium muticum	5	1	—	—	—	—	39.6	2	—	—	—	—	—	20
Solidago ohioensis	4	—	1	—	—	—	33.3	2	1	—	—	—	—	30
Equisetum arvense var. boreale	5	—	—	—	—	—	33.3	—	—	—	—	—	—	—
Parnassia glauca	2	2	—	—	—	—	26.4	—	—	—	—	—	—	—
Apios tuberosa	4	—	—	—	—	—	26.4	—	—	—	—	—	—	—
Typha latifolia	4	—	—	—	—	—	26.4	—	—	—	—	—	—	—
Lathyrus palustris	4	—	—	—	—	—	26.4	4	—	—	—	—	—	40
Scirpus validus	3	—	—	—	—	—	19.8	7	—	—	—	—	—	70

TABLE 2.—(*continued*)

	Betuletum pumillae potentillosum 15 quadrats 4-sq. m. Coverage classes							Dryopteridetum Thelypteridis eleocharosum 10 quadrats 1-sq. m Coverage classes						
	X	1	2	3	4	5	F-%	X	1	2	3	4	5	F-%
Boehmeria cylindrica var. Drummondiana	3	—	—	—	—	—	19.8	3	3	—	—	—	—	60
Campanula uliginosa	3	—	—	—	—	—	19.8	3	—	—	—	—	—	30
Viola cucullata	3	—	—	—	—	—	19.8	1	1	—	—	—	—	20
Calamagrostis canadensis	2	—	—	—	—	—	13.2	5	—	—	—	—	—	50
Agropyron subsecundum	2	—	—	—	—	—	13.2	—	—	—	—	—	—	—
Aster novae-angliae	2	—	—	—	—	—	13.2	—	—	—	—	—	—	—
Thalictrum dasycarpum	2	—	—	—	—	—	13.2	—	—	—	—	—	—	—
Impatiens biflora	2	—	—	—	—	—	13.2	3	—	—	—	—	—	30
Sanicula marilandica	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Valeriana uliginosa	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Erigeron philadelphicus	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Tofieldia glutinosa	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Solidago uliginosa	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Eleocharis palustris	1	—	—	—	—	—	6.6	2	7	—	—	—	—	90
Scutellaria galericulata	1	—	—	—	—	—	6.6	5	—	—	—	—	—	50
Lythrum Salicaria	1	—	—	—	—	—	6.6	1	5	1	—	—	—	70
Rudbeckia hirta	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Fragaria virginiana	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Lilium michiganense	1	—	—	—	—	—	6.6	—	—	—	—	—	—	—
Solidago graminifolia var. Nuttallii	—	—	—	—	—	—	—	6	—	—	—	—	—	60
Hypericum virginicum var. Fraseri	—	—	—	—	—	—	—	3	—	—	—	—	—	30
Galium boreale	—	—	—	—	—	—	—	2	—	—	—	—	—	20
Cardamine pratensis var. palustris	—	—	—	—	—	—	—	2	—	—	—	—	—	20
Eupatorium perfoliatum	—	—	—	—	—	—	—	1	—	—	—	—	—	10
Cicuta maculata	—	—	—	—	—	—	—	1	—	—	—	—	—	10
Panicum implicatum	—	—	—	—	—	—	—	1	—	—	—	—	—	10

communities. Since the crown cover of the shrubs is only locally dense, nearly all of the species of the herbaceous fen occur also in the shrub community, while many new ones appear under the more favorable conditions of the shrub stage.

Around portions of the shore where there is little or no development of herbaceous marsh, a mixed shrub community may occur. Here the *Betula* and *Potentilla* occur, but play comparatively insignificant roles. The dogwoods and willows mentioned before are important, and *Rosa palustris* is often abundant, as are *Rhamnus alnifolia* and *Rhus Vernix* (fig. 4).

The succession from the *Eleocharidetum palustris charosum* in shallow water through the herbaceous to the shrubby marsh has every appearance of being a rapid one, but this proves not at all to be the case. In the area where

the quadrats for table 2 were taken the marsh has a total breadth of only about 75 to 100 feet, formed since the initiation of the lake in early post-glacial time. The *Chara* communities from open water up to the water's edge are currently forming marl. The marsh communities are forming peat. A drill hole in the marsh, back only about 20 feet from the water's edge, reveals about 8 feet of peat lying over about 15 feet of marl below which lie sands and clays. In the light of the total thickness of the sedimentary column, it would seem that at least several centuries have been required to advance the margin of the marsh as little as 20 feet.

Swamp forest communities.—It is, of course, the fate of the shrubby marsh to be invaded by trees. Although the tall shrub, or small tree, *Rhus Vernix*, sometimes pioneers this invasion, there is no evidence at Sodon that it forms a definite stage. The first invading tree species capable of forming a closed canopy seems to be the tamarack, *Larix laricina*. It is a conspicuous invader of the shrubby marsh near the inlet and forms an interrupted fringe around much of the lake. The development of this stage is so slight at Sodon, however, that it was not practical to attempt a quantitative analysis of its structure. Other trees capable of invading the marsh and of growing on the shore where the marsh is absent include the elms, ashes, and red maple. The swamp forest community, rooted in peat, is primarily that with red maple dominant or codominant. The stand in which red maple is dominant is des-

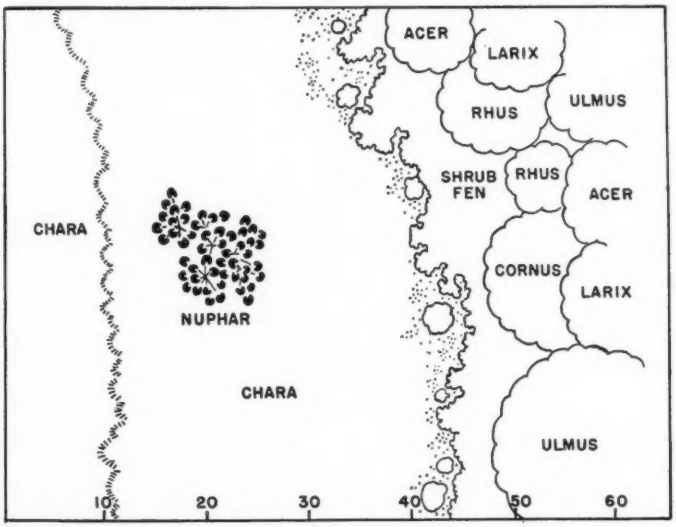

Fig. 4.—Sketch map of lake margin (scale in feet) showing a water lily colony on the *Chara* "shelf," and a mixed shrub fen bordering the lake without an intermediate herb fen.

ignated as *Aceretum rubri.* The variant next to the lake in which the tamarack is important is called the *Aceretum rubri laricosum,* and other stands where elms are abundant are referred to as the *Aceretum rubri ulmosum.*

Aceretum rubri and the variant *laricosum* were studied in some detail (tables 3-6, figs. 5-6). Whether or not one subscribes to the unistratal association hypothesis, it is certainly practical to analyze separately each important life-form community or synusia. We have consequently treated independently the tree, shrub, herb, and moss layers, adapting the sampling to the life-form

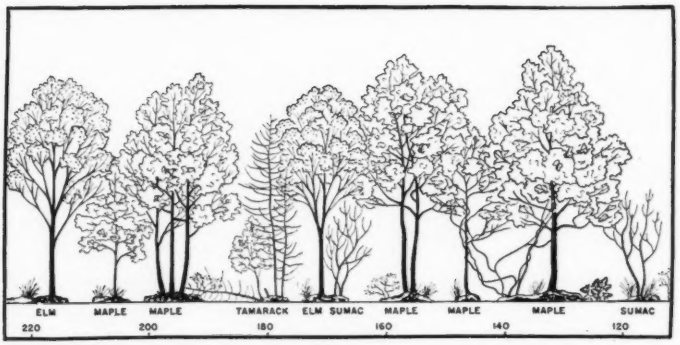

Fig. 5.—Line profile drawing radial to the lake showing typical Aceretum rubri on peat (scale in feet).

TABLE 3.—Certain sociological characteristics of the tree layer of the red maple swamp forest, Sodon Lake.

Area sampled:	Aceretum rubri 10 quadrats 100-sq.m.			Aceretum rubri laricosum 10 quadrats 100-sq.m.		
Total density i.e. number of stems	147			187		
Total coverage, as sq. ft. basal area	37.60			29.41		
	Density %	Basal area %	Frequency %	Density %	Basal area %	Frequency %
Acer rubrum	74.1	61.2	100	37.4	20.7	100
Larix laricina	2.7	1.4	10	31.0	36.7	100
Ulmus fulva	7.5	10.1	40	17.6	34.3	100
Fraxinus americana	0.7	*	10	3.7	0.2	40
Populus tremuloides	2.0	3.3	10	3.7	4.1	30
X Betula Sandbergi	—	—	—	5.3	2.0	10
Ulmus americana	7.5	11.1	50	1.1	2.0	10
Quercus rubra	1.4	0.1	20	—	—	—
Salix alba var. vitellina	1.4	9.8	10	—	—	—
Fraxinus nigra	2.7	3.0	20	—	—	—

* negligible

of the dominants. For the trees and shrubs there was separate sampling of the typical red maple swamp forest and of the marginal strip rich in tamarack. Although three species were found in the typical portion of the red maple swamp forest that were not sampled in the variant, and one, the peculiar birch which seems to be *X Betula Sandbergi*, was sampled only in the *laricosum*, these are not significant differences. The *Salix* is a chance escape from a planting near the boathouse and the others might equally well occur in either area. The difference is essentially that of the proportions of the constituent

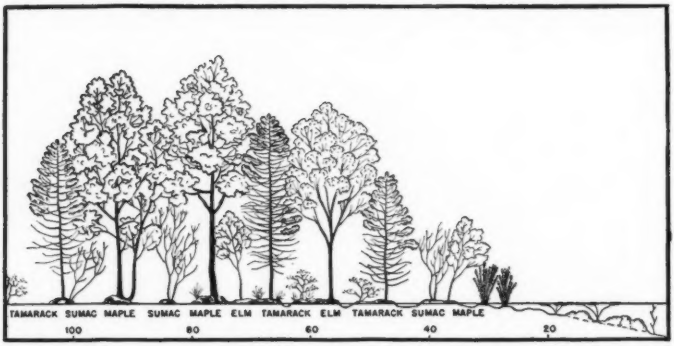

Fig. 6.—Line profile drawing of typical Aceretum rubri laricosum, continuing figure 5.

elements, except for *Larix* which seems soon to be overtopped and shaded out by the broadleaf species where the watertable is slightly lower. This effect is illustrated in the profile drawing (fig 5). These forest types here occur rooted in peat, although at the periphery there is inwash of sand and silt from the surrounding morainal hills.

In the red maple swamp forest the surface is sometimes comparatively level, and in such places the development of both the shrub and the herb layers may be more complete, but in much of the area the soil surface is very irregular. Here it consists of peaty stools compactly covered by bryophytes and held up by the arched roots of the trees, especially the red maple (fig. 5). In between are depressions, 10 to 15 inches deep, in which water stands during the wet seasons. As a consequence of these features, the shrub layer is fragmentary and the herbaceous layer of the depressions develops late in the season and is somewhat different from that of the slightly higher ground. Table 5 shows some of the qualitative and quantitative differences as revealed by the quadrats.

Mosses are generally absent from the seasonally flooded depressions of the red maple swamp forest, but on the peaty stools which surround the tree bases and elevated roots there is usually a heavy cover of mosses. In table 6 are some qualitative data that show the typical moss flora. A small sward

was removed from each different patch on the peaty stools of ten trees taken at random. Nearly every species was found to be dominant on at least one sward, but the most characteristic species of this biotope* at Sodon Lake seem to be *Tetraphis pellucida, Thuidium delicatulum, Leucobryum glaucum, Mnium cuspidatum, Pohlia nutans,* and *Aulacomnium palustre.* Where the soil is more mucky than peaty certain additional species occurred occasionally,

TABLE 4.—Certain sociological characteristics of the shrub layer of the Aceretum rubri and Aceretum rubri laricosum, Sodon Lake.

Area sampled:	Aceretum rubri 20 quadrats 4-sq. m. Coverage classes X 1 2 3 4 5	F-%	Aceretum rubri laricosum 20 quadrats 4-sq. m. Coverage classes X 1 2 3 4 5	F-%
Ilex verticillata	— 2 5 1 1 1	50	10 2 — — — —	60
Solanum Dulcamara	4 3 — — — —	35	7 2 — — — —	45
Cornus racemosa	2 2 1 1 — —	30	2 4 5 6 3 —	100
Rubus triflorus	5 — 1 — — —	30	7 5 2 3 — —	85
Rubus strigosus	1 2 1 — — —	20	6 1 1 — — —	40
Aronia melanocarpa	— 2 1 — — —	15	3 — — — — —	15
Rhus Vernix	— — 1 — 1 —	10	2 2 3 3 1 —	55
Cornus stolonifera	— 1 — 1 — —	10	2 2 2 — — —	30
Sambucus canadensis	— 2 — — — —	10	1 — — — — —	5
Spiraea alba	2 — — — — —	10	1 — — — — —	5
Vitis vulpina	— — — 1 — —	5	10 — — — — —	50
Rosa palustris	— — — — — 1	5	2 3 2 — — —	35
Rhus radicans	1 — — — — —	5	4 1 — — — 1	25
Vaccinium sp. 3	— 1 — — — —	5	— — — — — —	—
Nemopanthus mucronata	1 — — — — —	5	— — — — — —	—
Gaylussacia baccata	— 1 — — — —	5	— — — — — —	—
Vaccinium sp. 4	— 1 — — — —	5	— — — — — —	—
Salix discolor var. latifolia	— 1 — — — —	5	— — — — — —	—
Ribes americana	— 1 — — — —	5	— — — — — —	—
Rhamnus alnifolia	— — — — — —	—	7 2 2 — — —	55
Parthenocissus quinquefolia	— — — — — —	—	11 — — — — —	55
Viburnum Lentago	— — — — — —	—	4 — — — — —	20
Vaccinium sp. 1	— — — — — —	—	1 — — — — —	5
Vaccinium sp. 2	— — — — — —	—	1 — — — — —	5
Grossularia Cynosbati	— — — — — —	—	1 — — — — —	5
Lonicera canadensis	— — — — — —	—	1 — — — — —	5
Viburnum trilobum	— — — — — —	—	1 — — — — —	5
Betula pumila	— — — — — —	—	— 1 — — — —	5
Tree reproduction				
Ulmus fulva	5 2 1 — — —	40	2 1 1 — — —	20
Fraxinus americana	2 — — — — —	100	6 1 5 — — —	60
Acer rubrum	1 1 — — — —	10	5 2 — 1 — —	40
Populus tremuloides	2 — — — — —	10	3 — — — — —	15
Prunus serotina	1 — — — — —	5	5 1 — — — —	30
Quercus borealis var. maxima	1 — — — — —	5	1 — — — — —	5
Prunus virginiana	— — — — — —	—	1 1 — — — —	10
Amelanchier arborea	— — — — — —	—	1 — — — — —	5

* *Biotope* is used in the sense of the smallest natural area characterized by homogeneous conditions of topography, habitat, and biota.

such as *Climacium americanum* Brid., *Mnium punctatum* var. *elatum* Schimp., *Fissidens adiantoides* Hedw., *Sphagnum* (*acutifolium*), and *Conocephalum conicum* (L.) Dumort., as well as some of those listed in table 6.

TABLE 5.—Certain sociological characteristics of the herbaceous layer of the Aceretum rubri, Sodon Lake.

	Plants on the wet interstool flats 20 quadrats 1-sq.m. Coverage classes							Plants on somewhat higher land 10 quadrats 1-sq. m. Coverage classes						
	X	1	2	3	4	5	F-%	X	1	2	3	4	5	F-%
Boehmeria cylindrica		1	7	7	4	1	100		5	1	3			90
Dryopteris spinulosa									4	1	2			60
Glyceria striata		3	4				35		1		1			20
Onoclea sensibilis			1	2	2	1	35			1				10
Osmunda regalis var. spectabilis					2		10				2	1		30
Impatiens biflora		3	2				25		1	2				30
Viola cucullata									1	1				20
Dryopteris Thelypteris var. pubescens		1	3				20							
Athyrium angustum var. rubellum										1				10
Solidago caesia									1					10
Bidens cernua			1				5		1					10
Osmunda Claytoniana										1				10
Arisaema atrorubens var. zebrina									1					10
Symplocarpus foetidus			1				5		1					10
Scutellaria galericulata									1					10
Galium Aparine									1					10
Carex laxiflora									1					10
Ranunculus abortivus									1					10
Epilobium glandulosum var. adenocaulon			1				5							
Galium boreale		1					5							
Woody plants														
Solanum Dulcamara		2	5	4			55		2	2	3			70
Ulmus fulva									5					50
Rubus triflorus		1					5		3					30
Parthenocissus quinquefolia									3					30
Rosa palustris									1	1				20
Rhamnus alnifolia									1	1				20
Fraxinus americana									1			1		20
Rubus strigosus										1				10
Ilex verticillata											1			10
Rhus radicans										1				10
Vitis vulpina									1					10

TABLE 6.—Bryophytes of the peaty stools of trees of the Aceretum rubri, sampled at 10 stations, Sodon Lake.

Species	Number of patches or stands D d x	Number of stations represented
Amblystegium serpens (Hedw.) BSG.	1 1 1	3
Amblystegium varium (Hedw.) Lindb.	1 — —	1
Aulacomnium heterostichum (Hedw.) BSG.	1 — —	1
Aulacomnium palustre (Hedw.) Schwaegr.	4 4 3	7
Brachythecium sp. (sterile)	1 — —	1
Brotherella recurvans (Michx.) Fleisch.	1 — —	1
Dicranum scoparium (L.) Hedw.	1 — —	1
Dicranum undulatum Turner	1 — —	1
Geocalyx graveolens (Schrad.) Nees	— — 2	1
Helodium paludosum (Sulliv.) Aust.	2 1 —	2
Heterophyllium Haldanianum (Grev.) Kind.	1 1 —	2
Hypnum curvifolium Hedw.	1 — —	1
Leucobryum glaucum (Hedw.) Schimp.	5 2 3	7
Mnium cuspidatum (L.) Leyss.	5 2 6	6
Mnium punctatum L.	2 — 2	3
Pohlia nutans (Hedw.) Lindb.	7 2 —	6
Polytrichum juniperinum Hedw.	— 1 1	1
Polytrichum ohioense Ren. & Card.	— 1 —	1
Sphagnum (?squarrosum Crome)	1 — —	1
Tetraphis pellucida Hedw.	6 2 4	6
Thudium delicatulum (L. Hedw.) Mitt.	5 — —	5

D = dominant; d = codominant; x = present.

On the sedimentary soils of the old lake basin where the surface has been built up to 12 to 18 inches above the watertable, the *Aceretum rubri* seems to be replaced by various floristic combinations commonly associated with floodplains. Here may be included the *Aceretum rubri ulmosum* and stands of *Ulmus* with various proportions of such species as ash and basswood. Some of the combinations occurring at Sodon Lake in fragmentary stands are shown in table 7, together with two examples of upland types. Their herbaceous associates occurring on minimal area stands are listed in table 8.

There is no evidence in the immediate vicinity of Sodon Lake that the climax association of the area is beech-maple, but elsewhere in the County on the more mature soils which are neither conspicuously heavy nor light and in mesic situations beech-maple is capable of succeeding oak-hickory. It seems reasonable, then, to interpret the upland oak-hickory forest, remnants of which surround Sodon Lake, as very long-enduring late subclimax communities.

Our description of the vegetation of Sodon Lake has followed simultaneously (1) the successional sequence from open water to the forest communities on the sedimentary soils of the basin, (2) the life-form, and (3) the ecological changes. It seems that the various floristic combinations or communities of plants reflect both the historical processes of succession and the concomitant ecological changes. In this case at least these are natural areas with which

TABLE 7.—Selected single plots (100 sq. m. each) to show types of forest composition, Sodon Lake. D = Percent density or number of stems. C = Percent coverage, computed from basal area.

	ACERETUM						ULMETUM								QUERCETUM			
	Semi-annual inundation						Occasional inundation: high watertable								Low watertable			
	D%	C%	D%	C%	D%	C%	D%	C%	D%	C%	D%	C%	D%	C%	D%	C%	D%	C%
Larix laricina	27	31	—	—	—	—	—	—	—	—	—	—	7	*	—	—	—	—
Acer rubrum	54	34	75	81	23	54	—	—	17	2	—	—	14	11	—	—	—	—
Ulmus fulva	14	29	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Populus tremuloides	5	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ulmus americana	—	—	16	7	12	41	87	100	50	70	20	25	14	39	—	—	—	—
Fraxinus nigra	—	—	8	12	—	—	—	—	17	*	—	—	7	*	—	—	—	—
Prunus serotina	—	—	—	—	60	5	—	—	—	—	—	—	—	—	12	*	—	—
Sassafras albidum	—	—	—	—	5	*	—	—	—	—	—	—	—	—	—	—	37	21
Fraxinus americana	—	—	—	—	—	—	13	*	17	28	73	74	36	27	8	*	6	12
Tilia americana	—	—	—	—	—	—	—	—	—	—	7	*	21	23	—	—	—	—
Quercus alba	—	—	—	—	—	—	—	—	—	—	—	—	—	—	44	89	19	5
Carya ovata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	1	—	—
Quercus rubra	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8	9	—	—
Quercus velutina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	*	31	62
Amelanchier arborea	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	*	6	*
Total stems per plot	22		24		17		23		12		15		14		25		16	
Total basal area: sq. ft.		3.28		4.72		8.98		4.28		8.61		4.88		5.68		5.60		3.66

* less than ½%.

fuller biological phenomena can be correlated. Although it is recognized that a study like this often is considered to be incomplete without quantitative data on the apparently more critical environmental factors, and although it is equally apparent that the processes of action, reaction, and coaction in communities always involve animals as well as plants, it seems that the major basis of such small natural areas is formed by plants. It is on this assumption that this study is published as a preliminary account to be followed by others which will round out better the picture of the ecosystems involved.

TABLE 8.—Herbs of the Sodon Lake forest types occurring on minimal area stands.

	Red maple	Elm	White oak	Black oak
Boehmeria cylindrica	D	—	—	—
Dryopteris spinulosa	X	—	—	—
Glyceria striata	X	X	—	—
Onoclea sensibilis	d	X	—	—
Osmunda regalis var. spectabilis	d	—	—	—
Impatiens biflora	X	D	—	—
Viola cucullata	X	—	—	—
Dryopteris Thelypteris var. pubescens	X	—	—	—
Athyrium angustum var. rubellum	X	—	—	—
Solidago caesia	X	D	X	X
Bidens cernua	X	—	—	—
Osmunda Claytoniana	X	—	—	X
Arisaema atrorubens f. zebrina	X	X	—	—
Symplocarpus foetidus	X	X	—	—
Scutellaria galericulata	X	X	—	—
Galium Aparine	X	X	—	—
Carex laxiflora	X	—	—	—
Ranunculus abortivus	X	—	—	—
Epilobium glandulosum	X	X	—	—
Galium boreale var. typicum	X	—	—	—
Hystrix patula	—	X	—	—
Circaea quadrisulcata var. canadensis	—	X	—	—
Pteridium latiusculum	—	X	—	—
Galium circaezans var. hypomalacum	—	X	X	—
Viola sororia	—	X	X	X
Urtica procera	—	d	—	—
Lycopus americanus var. Longii	—	X	—	—
Apocynum cannabium var. glaberrimum	—	X	—	—
Carex sp.	—	X	—	—
Typha latifolia	—	X	—	—
Bromus ciliatus	—	X	—	—
Asclepias phytolaccoides	—	X	—	—
Actea rubra	—	X	—	—
Lactuca spicata	—	X	—	—

TABLE 8—(*Continued*)

	Red maple	Elm	White oak	Black oak
Polygonatum pubescens	—	X	—	—
Geum virginianum	—	X	—	—
Cicuta maculata	—	X	—	—
Anemone virginiana	—	X	—	—
Equisetum arvense var. boreale	—	X	—	—
Bidens connata	—	X	—	—
Chelone glabra var. typica	—	X	—	—
Amphicarpa bracteata	—	X	X	—
Ranunculus recurvatus	—	X	—	—
Osmorhiza Claytoni	—	X	X	X
Smilacina racemosa var. cylindrica	—	X	X	X
Trillium grandiflorum	—	X	X	—
Helianthus sp.	—	X	—	—
Prunella vulgaris var. lanceolata	—	X	X	—
Leersia oryzoides	—	X	—	—
Fragaria virginiana	—	X	—	—
Aster junciformis	—	X	—	—
Carex pennsylvanica	—	—	D	X
Agrimonia rostellata	—	—	X	—
Geranium maculatum	—	—	X	X
Smilacina stellata	—	—	X	—
Aster macrophyllus	—	—	d	D
Corallorrhiza maculata	—	—	X	—
Prenanthes altissima	—	—	X	d
Thalictrum dioicum	—	—	X	X
Desmodium acuminatum	—	—	d	X
Viola pubescens var. Peckii	—	—	—	d
Hepatica americana	—	—	—	d
Aralia nudicaulis	—	—	—	X
Botrychium virginianum	—	—	—	X
Sanicula marilandica	—	—	—	X
Total coverage	20%	80%	45%	40%

REFERENCES

CAIN, STANLEY A. 1947—Characteristics of natural areas and factors in their development. Ecol. Monogr. 17: 185-200.

———1948—Palynological studies at Sodon Lake: I. Size-frequency study of fossil spruce pollen. Science 108: 115-117.

——— AND LOUISE G. CAIN 1948—Palynological studies at Sodon Lake: II. Size-frequency studies of pine pollen, fossil and modern. Amer. Jour. Bot. 35: 583-591.

——— AND J. V. SLATER 1948—Palynological studies at Sodon Lake: III. The sequence of pollen spectra, profile I. Ecology 29: 492-500.

NEWCOMBE, C. L., AND J. V. SLATER 1948—The occurrence of temperatures unusual to American lakes. Science 108: 385-386.

——— AND ———1949—Temperature characteristics of Sodon Lake—A dichothermic lake in southeastern Michigan. Hydrobiologia 1 (In press).

——— AND W. T. PENFOUND 1938—Aceretum rubri: The red maple swamp forest of central Long Island. Amer. Midl. Nat. 19: 390-416.

STANLEY, G. M. 1936—Geology of the Cranbrook area. Cranbrook Inst. Sci. Bull. 6: 1-56, 11 pls., 12 figs., maps.

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TABLE 9.—Life-form Summary.

Symbol used in appendix	Life-form	Number	Per Cent
Ph	Phanerophytes, total	(58)	(28.4)
M(L)	Lianas, Microphanerophytes	5	2.5
MM	Mega-, Mesophanerophytes, exceeding 8 m. high	16	7.8
M	Microphanerophytes, 2-8 m. high	21	10.3
N	Nanophanerophytes, ¼-2 m. high	16	7.8
Ch	Chamaephytes	2	.9
H	Hemicryptophytes	102	50.2
G	Geophytes	20	9.9
HH	Helo-, Hydrophytes	14	6.9
Th	Therophytes, annuals	7	3.5
Total		203	99.8

APPENDIX

VASCULAR PLANTS OF SODON LAKE, OAKLAND COUNTY, MICHIGAN*

MM Acer rubrum L.
G Actea pachypoda Ell.
G Actea rubra (Ait.) Willd.
H Agrimonia rostellata Wallr.
H Agropyron subsecundum (Link) Hitchc.
M Amelanchier interior Nielsen
M Amelanchier sanguinea (Pursh) DC.
H Amphicarpa bracteata (L.) Fern.
HH Anacharis canadensis (Michx.) Planchon.
H Anemone virginiana L.
G Apocynum cannabinum var. glaberrimum A. DC.
H Aralia nudicaulis L.
G Arisaema atrorubens f. viride (Engler) Fern.
G Arisaema atrorubens f. zebrina (Sims) Fern.
M Aronia melanocarpa (Michx.) Ell.
H Asclepias incarnata L.
G Asclepias phytolaccoides Pursh.
H Aster junciformis Rydb.
H Aster lateriflorus (L.) Britt.
H Aster macrophyllus L.
H Aster Novae-angliae L.
H Aster prealtus Poir.
H Aster umbellatus Mill.
H Athyrium angustum var. rubellum (Gilbert) Butters.
H Barbarea vulgaris R. Br.
N Berberis Thunbergii DC.
N Betula pumila L.
M X Betula Sandbergi Britt.
Th Bidens cernua L.
Th Bidens cernua f. minima (Huds.) Parss.
Th Bidens connata Muhl.
G Boehmeria cylindrica (L.) Sw.

* This list includes only plants found in the lake or growing on the sedimentary soils within the boundary of the original lake basin.

G Boehmeria cylindrica var. Drummondiana Weddell.
H Bromus ciliatus L.

H Calamagrostis canadensis (Michx.) Beauv.
G Calopogon pulchellus (Salisb.) R. Br.
H(HH) Caltha palustris L.
H Campanula rotundifolia var. intercedens (Witasek) Farw.
H Campanula uliginosa Rydb.
H Cardamine pratensis var. palustris Wimm. & Graeb.
H Carex aurea Nutt.
H Carex crinita Lam.
H Carex hystricina Muhl.
H Carex intumescens var. Fernaldii Bailey.
H Carex laxiflora Lam.
H Carex leptalea var. Harperi (Fern.) Stone.
G Carex pennsylvanica Lam.
H Carex scoparia Schkuhr.
H Carex stipata Muhl.
MM Carya glabra (Mill.) Sweet.
M(L) Celastrus scandens L.
HH Ceratophyllum demersum L.
N Chamaedaphne calyculata (L.) Moench.
H Chelone glabra var. typica Pennell.
H Cicuta bulbifera L.
H Cicuta maculata L.
G Circaea quadrisulcata var. canadensis (L.) Hara.
H Cirsium muticum Michx.
H Coptis groenlandica (Oeder) Fern.
G Corallorrhiza maculata Raf.
M Cornus florida L.
N(M) Cornus racemosa Lam.
N(M) Cornus stolonifera Michx.

H Desmodium acuminatum (Michx.) DC.
H Dryopteris cristata (L.) A. Gray.
H Dryopteris spinulosa (Mull.) Walt.
H Droypteris Thelypteris var. pubescens (Lawson) A. R. Prince.

HH Eleocharis palustris (L.) R. & S.
H Epilobium glandulosum var. adenocaulon (Haussk.) Fern.
G Equisetum arvense var. boreale (Pong.) Bupr.
H Erigeron philadelphicus L.
H Eupatorium maculatum L.
H Eupatorium perfoliatum L.

H Fragaria virginiana Duchesne
MM Fraxinus americana L.
MM Fraxinus lanceolata Borkh.
MM Fraxinus nigra L.

Th Galium Aparine L.
H Galium boreale var. typicum Beck von Man.
H Galium circaezans var. hypomalacum Fern.
N Gaylussacia baccata (Wang.) K. Koch.
H Gentiana procera Holm.
H Geranium maculatum L.
Th Gerardia paupercula var. borealis (Penn.) Penn.
H Geum aleppicum var. strictum (Ait.) Fern.
H Geum virginianum L.
H Glyceria striata (Lam.) Hitchc.
N Grossularia Cynosbati (L.) Mill.

M Hamamelis virginiana L.
H Helianthus giganteus L.
H Helianthus sp.
H Hepatica americana (DC.) Ker.
H Hypericum virginicum var. Fraseri (Spach.) Fern.
H Hystrix patula Moench.

M Ilex verticillata (L.) Gray.
Th Impatiens biflora Walt.

H Juncus alpinus Vill.

H Lactuca spicata (Lam.) Hitchc.
MM Larix laricina (Du Roi) Koch.
H Lathyrus palustris L.
H Leersia oryzoides (L.) Sw.
HH Lemna minor L.
G Lilium michiganense Farw.
H Liparis Loesellii (L.) Rich.
H Lobelia Kalmii L.
N Lonicera canadensis Marsh.
HH Ludwigia palustris var. americana (DC.) Fern. & Grisc.
H Luzula multiflora (Ehrh.) Lejeune.
H Lycopus americanus var. Longii Benner
H(HH) Lathryum Salicaria L.

H Maianthemum canadense Desf.
HH Menyanthes trifoliata var. minor Michx. ex Raf.

M Nemopanthus mucronata (L.) Trel.
HH Nuphar variegatum Engelm.
HH Nymphaea odorata Ait.

G Onoclea sensibilis L.
G Onoclea sensibilis f. hemiphyllodes

(Kiss. & Kumm.) Wetherby.
H Osmorhiza Claytonia (Michx.) Clarke.
H Osmunda Claytoniana L.
H Osmunda regalis var. spectabilis (Willd.) A. Gray.

H Panicum commutatum Schultes.
H Panicum implicatum Scribn.
H Parnassia glauca Raf.
M(L) Parthenocissus quinquefolia (L.) Planch.
G Polygonatum pubescens (Willd.) Pursh.
MM Populus grandidentata Michx.
MM Populus tremuloides Michx.
HH Potamogeton (?angustifolius Berch. & Presl) sterile
HH Potamogeton foliosus Raf.
HH Potamogeton pusillus var. typicus Fern.
HH Potamogeton panormitans Biv.
HH Potamogeton pectinatus L.
N Potentilla fruticosa L.
H Prenanthes alba L.
H Prenanthes altissima L.
H Prunella vulgaris var. lanceolata (Bart.) Fern.
M Prunus americana Marsh.
MM Prunus serotina Ehrh.
MM Prunus virginiana L.
H Pycnanthemum virginianum (L.) Dur. & Jack.
H Pyrola elliptica Nutt.
H Pyrola rotundifolia var. americana (Sweet) Fern.

MM Quercus alba L.
MM Quercus rubra L.

H Ranunculus abortivus L.
H Ranunculus recurvatus Poir.
Th Ranunculus scleratus f. natans Gluck.
HH Ranunculus trichophyllus Chaix.
M Rhamnus alnifolia L'Her.
M(L) Rhus radicans L.
M Rhus Vernix L.
N Ribes americana Mill.
N Rosa palustris Marsh.
H(N) Rubus strigosus Michx.
Ch(H) Rubus triflorus Richards.
H Rudbeckia hirta L.
H Rumex Brittanica L.

HH Sagittaria latifolia Willd.
M Salix alba var. vitellina (L.) Stokes.
M Salix Bebbiana Sarg.
N Salix candida Flugge.
M Salix discolor var. latifolia Anders.
M Salix lucida Muhl.
M Salix petiolaris (Bailey) Fern.
M Salix serissima (Bailey) Fern.
N Sambucus canadensis L.
H Sanicula marilandica L.
MM Sassafras albidum (Nutt.) Nees.
HH Scirpus validus Vahl
H Scutellaria galericulata L.
H Senecio aureus L.
G Smilacina racemosa var. cylindrica Fern.
G Smilacina stellata (L.) Desf.
H Smilax herbacea L.
N Solanum Dulcamara L.
H Solidago altissima L.
H Solidago caesia L.
H Solidago graminifolia var. Nuttallii (Greene) Fern.
H Solidago ohioensis Riddel.
H Solidago patula Muhl.
H Solidago rugosa Mill.
H Solidago uliginosa Nutt.
N Spiraea alba DuRoi.
G Symplocarpus foetidus (L.) Nutt.

H Taenidia itegerrima (L.) Drude.
H Taraxacum laevigatum (Willd.) DC.
H Thalictrum dasycarpum Fisch. & Lall.
H Thalictrum dioicum L.
MM Tilia americana L.
H Tofieldia glutinosa (Michx.) Pers.
HH Typha latifolia L.

MM Ulmus americana L.
MM Ulmus fulva Michx..
H Urtica procera Muhl.

Ch Vaccinium Oxycoccos L.
N Vaccinium vacillans Kalm ex Torrey
H Valeriana uliginosa (T. & G.) Rydb.
N Viburnum acerifolium f. ovatum Rehder.
M Viburnum dentatum L.
M Viburnum Lentago L.
M Viburnum trilobum Michx.
H Viola cucullata Ait.
H Viola incognita var. Forbesii Brainerd.
H Viola papilionacea Pursh.
H Viola pubescens Ait.
H Viola pubescens var. Peckii House.
M(L) Vitis aestivalis Michx.
M(L) Vitis vulpina L.

HH Zanichellia palustris var. major (Boem.) Koch.

Dryopteris Hybrids

Albert Chandler
Kirkwood, St. Louis Co., Mo.

In *Dryopteris* most botanists include two rather obviously unlike groups of ferns. These differ in North America even in their geographical centers, and in the number of vascular bundles in their stipes. One is most abundant in the North, and the other limits the greater number of its species to the Gulf States. Not one of the nineteen *Dryopteris* hybrids, from the Atlantic Coast to the Rocky Mountains, crosses these two groups, though three representatives of the southern or *Thelypteris* section are scattered in the North. So we shall not be concerned here with relationships to the Massachusetts, the Marsh, or the New York Ferns.

It was stated as a rule by Ezra Brainerd, who was famous for his work with *Rubus* and *Viola*, that hybrids between distinct but nearly related species have (1) characters intermediate between unlike features of the parents; (2) grow vigorously; (3) are more or less infertile from defective pollen; and (4) that their offspring resemble one another with fixed characters. But hybrids between doubtfully distinct species, as between a species and its varieties, exhibit (1) various combinations of the parents' unlike features instead of blending these in an intermediate form; (2) some specimens will resemble one parent, and others the other, and still others may sport; and (3) fertility is unimpaired.

Dryopteris hybrids should offer opportunities to test these rules. For example, the fact that Boott's Fern fails to show erratic forms has been urged to cast doubt on its hybridity, but instead would tend to support the first rule, as its parents seem remote; here the doubt, if any, must rest on its fertility. Again J. K. Small said of the Log Fern, whose parents seem close, that "the technical characters ascribed to it do not seem to be constant," which would tend to support the second rule. And perhaps the most interesting subject for speculation is the Crested Marginal Fern, whose outline is fixed but whose details are most erratic of all; its parents seem neither remote nor obviously close.

But by what criteria are we to decide whether the parents are close or remote? The outline, glandularity, habitat, cutting, or what else? In the absence of at least a convenient rule-of-thumb to separate those which are close from those which are remote, Brainerd's rules will not stand the pragmatic test among ferns.

Tentatively, may we refer *Dryopteris* hybrids to four rather distinct sources? 1. The *cristata-clintoniana—goldiana complex* or series; 2. the *intermedia—spinulosa series* (including *campyloptera*); 3. the *filix-mas—marginalis group;* and 4. *fragrans* var. *remotiuscula* off by itself and so different that it may come to us from a geologic past of its own.

In the alphabetical list of hybrids below, if the parents come from different sources, above, one of them is italicized. And as botanists disagree as to which are species and which are varieties, so as to distinguish hybrids from crosses, we must use the popular term "hybrid" for both alike. The list follows:

D. campyloptera	x intermedia*	
D. clintoniana	x cristata*	
D. clintoniana	x goldiana	(Log Fern: D. celsa)
D. clintoniana	x *intermedia**	
D. clintoniana	x marginalis*	
D. clintoniana	x *spinulosa**	
D. cristata	x goldiana	(D. atropalustris)
D. cristata	x *intermedia*	(Boott's Fern)
D. cristata	x marginalis	(Crested Marginal Fern)
D. cristata	x *spinulosa**	
D. filix-mas	x marginalis*	
D. filix-mas	x *spinulosa**	
D. fragrans	x *intermedia**	
D. goldiana	x *intermedia*	(D. separabilis)
D. goldiana	x marginalis	(D. leedsii)
D. goldiana	x *spinulosa**	
D. intermedia	x *marginalis**	
D. intermedia	x spinulosa	(D. intermedia var. fructuosa)
D. marginalis	x *spinulosa*	(D. pittsfordensis)

Nobody knows how far the rules, by which horticulturists are guided in creating new varieties of seed plants, apply in breeding from spores. Besides the Mendelian laws, horticulturists have derived from their experience, perhaps not a rule, but at least an expectation, that the progeny is somewhat more likely to inherit the stature and vigor of the mother plant, but peculiarities of form or color from the pollen parent. They expect that *Van Fleet* x *Eclipse* (the pink climbing rose as seed-bearer and the dwarf yellow for pollen), will differ from *Eclipse* x *Van Fleet*, the reverse cross between the same two plants, thus creating two different horticultural varieties. To separate them and indicate the parental relationships, it is conventional, among horticulturists, to write the name of the mother plant first — ladies first. This is more precise than the convention, among botanists, to write the two species in alphabetical order, and thus fail to distinguish reciprocal crosses.** If the same tendencies exist in the prothalia of spore-bearing plants, seventy-two horticultural forms are at least mathematically possible from crossing the nine Shield Ferns which have been pointed out as putative parents of hybrids. This is shown by the following diagram (fig. 1) and would account for the multiplicity of variations.

With 72 possible crosses in the F_1 generation, with line-breeding back to their parents too, 6408 other combinations would be possible in the F_2 generation. It may not be worth while to contemplate so dizzy a phantasmagoria, if the conjectures of J. H. Fabre (Wonder Book of Plant Life, end of Ch. VI)

* There is no synonym. The recently described *D. filix-mas* x *oreopteris* (A. F. J. 34: 115 and 37: 53) is reported west of the range dealt with here.

** See Trelease, Naming American Hybrid Oaks, Proc. Amer. Phil. Soc. 56: 44 (1917) as to how to show dominance of one or the other parent. Unfortunately botanists generally neglect these suggestions.

were based on observations which included ferns: "More rarely hybrids are fertile, when their offspring are so likewise. . . . Nevertheless, the new form is far from stable; from one generation to another the mingled characteristics disappear, while the pristine characteristics are more strongly affirmed. Finally, sooner or later . . . separating that which hybridization brought together, the plant of itself returns to its origin, and thereby gives us the most striking example of the inflexible power appointed by the Creator to maintain the species unchanged."

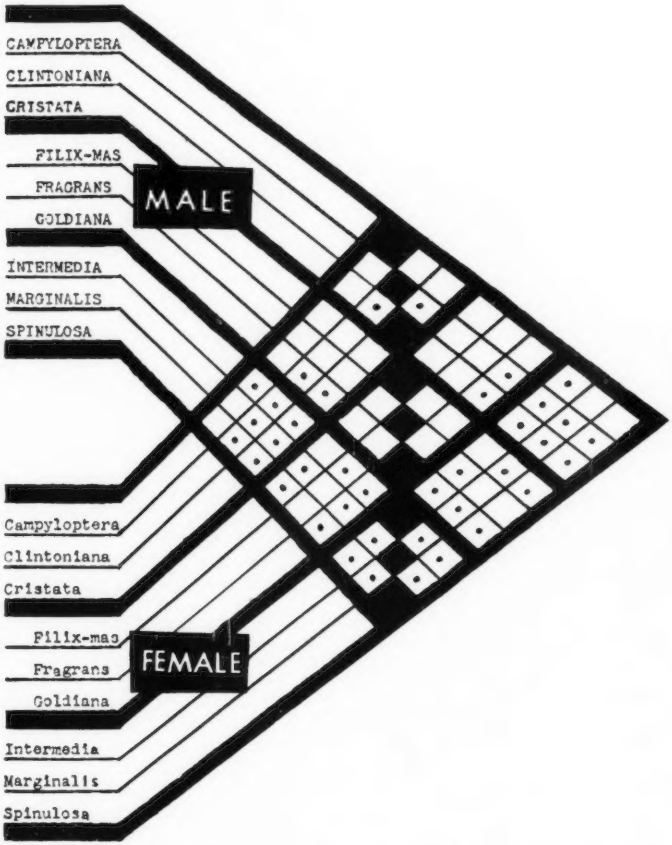

Fig. 1.—The 19 reported hybrids; parental functions being unknown, 39 crosses are indicated. Seventy-two intersections show limits of horticultural forms from 9 *Dryopteris* parents in the first generation.

Anyway, hybrids are not prescriptions in bottles, fixed by the alchemists of the wild. They are living streams — sprung from the confluence of two others — whose different elements persist or combine, disappear or unite from place to place and time to time. When the English historian, Freeman, came to America, he said that he wanted to see three things: a New England town meeting, Niagara Falls, and the confluence of the Mississippi and the Missouri. There is a gigantic hybrid. The clear waters of the Mississippi,

Fig. 2.—*D. clintoniana* x *marginalis* early generation hybrid?

coming down from the north, are shouldered over to the east by the turbid currents of the Missouri, yellow with the loess of the western plains. For miles below the confluence the two surge along side by side, with huge vibrant areas of the one rising within the borders of the other, and melting away. After they have blended, clear tributaries enter the tan mixture, and are similarly absorbed. Thus you have some hybridity exemplified on a continental scale.

In the *Torrey Bulletin 35:135, 36:41* Dowell in 1908 and Benedict in 1909 described 10 and mentioned 5 others of the 19 here, without discussing the possibility of reciprocal hybrids. These are suggested by such variations as appear in figures 2-5.

In fig. 2 we see elements combined but not compounded, "the top of one parent and the base of the other" as if grafted together. Not a rare form, this specimen might be considered an early-generation hybrid — whether first or second makes no difference for us here. Next (fig. 3) we see the same elements united, seemingly in a later-generation hybrid. Collected at Lake George, N. Y., by R. C. Benedict, both are in the herbarium of Brooklyn Botanic Garden, labeled *D. clintoniana* x *marginalis*.

In figs. 4 and 5 we see the first resembling one parent, and the second resembling the other. Both are from the Gray Herbarium, labeled *D. campyloptera* x *intermedia*, a great rarity reported by C. A. Weatherby in *American Fern Journal Vol. 26: 68*.

Among crosses of hybrid tea roses, a disappointing novelty may improve after a few years in commerce: The Doctor, for example. Such progress has been attributed to care in choosing bud-wood after material becomes plentiful. Yet that assumption, hazarded but not proved, is not the only possible explanation. If unbalanced hybrids are weak, as Fabre suggested, then among successive vegetative reproductions, which survive, there will be the appearance of elements tending to blend, and the better blends will be selected by propagators — as perhaps occurs in natural selection to produce at last so perfect a hybrid as *D. Boottii*. Yet in this last, as observed by M. G. Brooks (The Pteridophytes of West Virginia, p. 29) there is a correlation between frost resistance and resemblance to *D. intermedia*, while plants more like *D. cristata* wither early in the fall.

Here "questions like spirits may be raised with ease but vanquished with difficulty." Recently these have been suggested: Whence comes the greater glandularity of *D. intermedia* var. *fructuosa* if that be indeed the hybrid *D. intermedia* x *spinulosa*? Surely not from *spinulosa* which should dilute the glandularity of *intermedia*. Second, if *D. clintoniana* var. *australis* be the hybrid *D. clintoniana* x *dentata*, as hazarded by Brown and Correll in their excellent *Ferns of Louisiana*, how could it enter Missouri far north of the range of *dentata*? The only report is Steyermark's from one of the remotest untouched Ozark gulches. And such a hybrid would be unique in crossing the northern and southern sections of *Dryopteris*. There is one reply, rather

than answer, to such questions: All things are possible to the fairies and the ferns.

Range reports are deceptive. Few botanists being able to distinguish Shield Fern hybrids in the field, reports have marked the footsteps of the mighty, and that is about all. The experts were in the East, and the finds were in the East. Until a country is combed by competent observers, botanical ranges are simply unknown. The very first excursions of Butters and Tryon added hybrids from the shores of Lake Superior. Prophecy is hazardous, but

Fig. 3.—*D. clintoniana* x *marginalis* late generation hybrid?

for what this may be worth, look for hybrid ferns to emerge *into print* in the Middle West as botanical exploration there improves.

Rigid keys are hardly adapted to the transitory characters of hybrids still in a state of flux. Yet we may take a tabular view of the mass. The table below (fig. 6) may direct an inquirer into the section where he is likely to find his specimen among two or three alternatives at most.

Of some hybrids there are not enough specimens for even specialists to feel that they know all about them. Supplementing the tabular key, the following notes may be helpful:

Fig. 4.—*D. campyloptera* x *intermedia* resembling *intermedia*.

Boott's Fern, *D. cristata* x *intermedia*. In Indiana C. C. Deam[1] has not found the under surface of the blade to be minutely glandular, though it is usually so in Wisconsin according to Tryon,[2] and generally so in the East according to Dowell.[3] The position of the fruit-dots, near the midvein, differs from that of both the parents. The stipe scales are usually but not always pale and numerous.

D. campyloptera x *intermedia* is widely variable in leaf form. C. A. Weatherby, in a letter to the author, states that herbarium interpretation depends on glands not only on the indusia but also on the undersurface of midribs of the leaflets. Field interpretation depends on its intermediate color and mode of growth. Specimens resembling *campyloptera* are more finely cut than that parent. Northeastern.

D. clintoniana x *cristata* is a broader Crested Fern with more acuminate leaflets.

Fig. 5.—*D. campyloptera* x *intermedia* resembling *campyloptera*.

Commonly there are 4 to 6 fruit dots, in pairs, on a fertile pinnule, but as many as 10 in some of the middle leaflets, and none in the lower third of the blade. The stipe is dark, with very large scales, the rachis tan, and the rachillas polished and raised. New Jersey, New York and Vermont.

D. clintoniana x *goldiana* (*D. celsa*, Log Fern) has Clinton's outline but Goldie's basal leaflets lengthened to almost equal those above, and some but fewer of its thick scales from a quarter to half an inch long, some of them pale brown and merely dark-centered in a lighter periphery. Fronds few and erect, relatively narrower than either Goldie or *D. cristata* x *goldiana*. The falcate leaflets are deeply cut with 10 to 20 pairs of segments (See Fernald Key, Rh. 49: 104). Hummocks and stumps in acid swamps, North Carolina, Virginia, Maryland and perhaps to New England.

D. clintoniana x *intermedia* is more like Boott's Fern than any other, but larger and broader, less cut, more leaflets falcate, the teeth incurved, and the fruit-dots nearer the midvein and not large. Stipe scales are plentiful and usually dark-centered. It seems to be a more deeply cut *Clintoniana* with noticeable difference between fertile and sterile fronds. New Jersey, New York and New England.

D. clintoniana x *marginalis* is very variable, fruiting in all but the 2 or 3 lowest leaflets, the fruit-dots mostly medial but some approaching the margin and others approaching the midvein, from 4 to 6 pairs to a segment, regularly spaced. The stipe is characteristically shaggy below with reddish scales. The lower leaflets are usually horizontal, while those above are more and more falcate toward the tip, wider than in Crested Marginal Fern. Teeth are spinulose and appressed. Swamps, New Jersey to Massachusetts.

D. clintoniana x *spinulosa* resembles *D. clintoniana* x *intermedia* except for glandless indusia, and the general habit and cutting of the fronds which separate it also from *D. cristata* x *spinulosa*. The stipe and blade are about equal in length, the former dark below and pale above, with thin tan scales. The rachis is winged in the upper quarter, and the rachillas of the lower leaflets are also winged. The teeth claw forward, noticeable on the broad blunt leaflets and pinnules. Swampy woods, New England to Ohio.

D. cristata x *goldiana*, with blade widest at its base, rather a slender outline, and broad lower leaflets which are slightly narrowed at their bases or at least no wider than elsewhere, the head of this hybrid is not jammed down into its shoulders like Goldie's. The blunt outer segments often alternate as in the common polypody. The veins are very long, starting far below the tooth toward which they reach. Mostly in rich soil in coastal area, Connecticut to South Carolina, but reported also from central lowland Ohio. Minute details are described by J. K. Small, *Southeastern Ferns*, who gave it the name *D. atropalustris*.

Crested Marginal Fern, (*D. slossonae*, or *D. cristata* x *marginalis*) is a very irregular creation, generally resembling a narrow marginalis distinguished by medial fruit-dots, but even in the same plant some fronds are symmetrical and others unsymmetrical, some resembling one and some the other parent. Here as suggested in *Torry Bulletin 36: 44* (1909) the value of critical characters "seem to vary inversely with the size of the part of the plant examined." It is rather frequent on hummocks in swamps. In its shaggy stipe and ascending terminal leaflets, it resembles marginalis at both ends, but the basal third of the blade has the outline of cristata. From New Hampshire to Pennsylvania and Ohio.

D. cristata x *spinulosa* closely resembles Boott's Fern, except that both the indusia and the blade are glandless, the stipes are less chaffy with paler brown scales, and the blade is widest at the middle, less deeply cut, and narrower at the base. In short, a

1 Flora of Indiana, p. 46; 2 Ferns of Wisconsin, p. 48; 3 Torr. Bull. 35: 136.

glandless fern midway between its parents in size and cutting, more variable, and making large clusters that at first sight suggest *clintoniana*. Connecticut to Indiana and Wisconsin.

D. filix-mas x *marginalis*, rather upright and not evergreen, is intermediate between its parent in chaffiness, the darker upper and paler lower surface, the outlines of both the blades and leaflets, the veins and the position of the fruit-dots. The leaflets are pinnate in the lower third of the blade, then pinnatifid above. The pinnules are blunt, crenate rather than toothed, sometimes falcate in the basal part of the blade, and heavily fruited toward the tip. Rare but in rather large colonies where found. Massachusetts to Vermont.

The hybrid *D. filix* x *spinulosa*, known in Europe, is listed here only because the ranges of the parents overlap within the northern part of our area, and a lucky collector may pick it up by discerning intermediate characters.

D. fragrans x *intermedia*, reported by Tryon (A. F. J. 32: 81) at the foot of a north-facing cliff, in damp shady wooded talus, with no undiluted fragrans characters, is mostly a blend, but with some of the characters of intermedia, as the 5 vascular bundles in the long stipe, the abruptly tapering apex of the blade, and the gray or brown glands as distinguished from the tan or ruddy glands of fragrans. The hybrid differs from both parents in a tendency of its larger pinnules to overlap at the base of a leaflet Wisconsin.

D. separabilis (*D. goldiana* x *intermedia*) so named because the rather oblique leaflets of the fully 2-pinnate frond are more separated than in other Goldie progeny, though larger than its kindred, has been found only in the Dismal Swamps of Virginia and North Carolina, and in one county in Arkansas. It is described at great length in Small's *Ferns of the Southeastern States*.

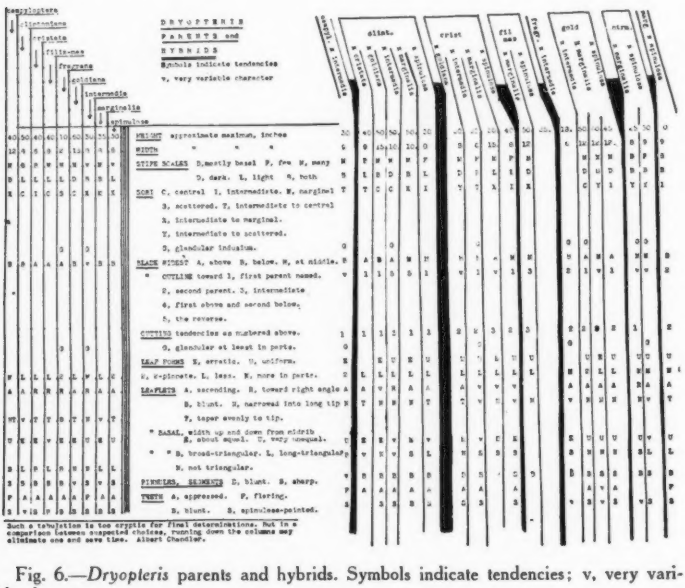
DRYOPTERIS
PARENTS and
HYBRIDS
Symbols indicate tendencies
v, very variable character
HEIGHT approximate maximum, inches
WIDTH
STIPE SCALES B,mostly basal F, few M, many
D, dark. L, light S, both
SORI C, central I, intermediate. M, marginal
S, scattered. T, intermediate to central
A, intermediate to marginal.
Y, intermediate to scattered.
G, glandular indusium.
BLACK RIDGES A, above B, below. M, at middle.
OUTLINE toward 1, first parent named.
2, second parent. 3, intermediate
4, first above and second below.
5, the reverse.
CUTTING tendencies as numbered above.
G, glandular at least in parts.
LEAF FORMS E, erratic. U, uniform.
S, s-pinnate. L, less. M, more in parts.
LEAFLETS A, ascending. R, toward right angle
B, blunt. N, narrowed into long tip
T, taper evenly to tip.
BASAL, width up and down from midrib
E, about equal. U, very unequal.
B, broad-triangular. L, long-triangular
N, not triangular.
PINNULES, SEGMENTS D, blunt. S, sharp.
TEETH S, appressed. F, flaring.
B, blunt. S, spinulose-pointed.
Such a tabulation is too cryptic for final determinations, but in a comparison between suspected choices, running down the columns may eliminate one and save time. Albert Chandler.
clint.
cris
fil mas
gold
marg.
spin.

Fig. 6.—*Dryopteris* parents and hybrids. Symbols indicate tendencies; v, very variable character.

Leeds' Fern (*D. goldiana* x *marginalis*) differs from the parents in general appearance, though variable details resemble one or else the other. Thus it is irregualrly intermediate, suggesting both a narrow Goldie (with its characteristic long dark scales) and a broad marginal (with its dark upper and paler under-surface). Shady rich woods with northern exposure. Pennsylvania to Vermont.

D. goldiana x *spinulosa*, with the size, habit, and indusia of Goldie; but with the finer marginal cutting, and oblique leaflets, and unequally triangular basal leaflets, and fruit-dots about midway between margin and midrib as in *spinulosa*.

D. intermedia x *marginalis* has blunt segments and pinnules, but sharp leaflets, and glandular indusia upon fruit-dots remote from the midvein. Dry woods, New England to Ohio and West Virginia.

D. fructuosa, or *intermedia* x *spinulosa*, is closer to the former but with leaflets tending to point obliquely upward and to taper evenly to their tips (the spinulosa pattern) with shorter pinnules and larger and more numerous and more glandular sori. Glands appear also on veins and segments. The lower basal pinnule of the basal leaflet is not always shortened. Newfoundland to West Virginia and Wisconsin.

The Pittsford Fern, *marginalis* x *spinulosa*, with both its blades and its leaflets long-pointed, has the leathery texture of *marginalis* which it resembles in the corklike character of the almost vertical older fruit-dots. But the claw-like teeth are those of *spinulosa*. More in detail, the shaggy stipe is 6 to 12 inches long, and the 2-pinnate blade about that wide, but twice as long, suggesting *campyloptera*, broadest just below the middle. The basal leaflets are the broadest, their superior pinnules much longer than the inferior. Scales are plentiful and brown, darker on the stipe than up the rachis. Fruit-dots are submarginal or else back from the margin, about halfway to the midvein. Vermont and New York.

Book Reviews

PLANTS AND ENVIRONMENT.—A Textbook of Plant Autecology. By R. F. Daubenmire. John Wiley & Sons, Inc., New York. 1947. 424 pp., 87 figs. $4.50.

Dr. Daubenmire's thorough training, wide experience, and long discipline in the field of autecology particularly qualifies him to write such a book as this. The style is smooth, the sentences clear and concise, and the chapters well organized. The book is a valuable contribution to ecological literature and fills an important place as a textbook for autecology and a supplementary text for general ecology courses.

The author divides the environmental factors into seven coordinate classes: soil, water, temperature, light, atmosphere, fire and biotic, to each of which he devotes a quite comprehensive chapter. This classification is somewhat unusual but the entire field of environment is quite thoroughly covered in the discourse. The factor *fire* might have been absorbed under "Atmosphere and Biotic" according to its origin just as orographic factors have been absorbed, but this is a matter of personal opinion and does not detract from the value of the book.

One chapter is devoted to the environmental complex in which the author makes clear that the environment consists of more than just the sum of the individual factors, but that fluctuating factors, compensating factors, and delayed effect, as well as microenvironment which usually goes unmeasured, all may contribute to the complexity of the habitat. In the last chapter, "Ecological adaptation and evolution," the author considers fixed variations as an environmental screening of genetic factors and those that lack survival are not considered adaptational. Much space is given to the application of Turesson's genecologic classification of variations.

A bibliography of 612 references in the English language has been included. English translations of such books as *Plant Geography*—Schimper, *Plant Sociology*—Braun-Blanquet, and *Oecology of Plants* by Warming are not included.

The book is well illustrated with excellent photographs and charts, most of which are original. There are but few errors such as omissions, mechanical errors and repetition, but they are too negligible to mention in a review of this length without unduly emphasizing them.

The author stated in the preface what he hoped to do. He accomplished his ends in a clear, concise, comprehensible and masterful way.—H. I. FEATHERLY, Oklahoma A. & M. College, Stillwater.

BIOLOGY OF PATHOGENIC FUNGI. Edited by Walter J. Nickerson, in cooperation with R. W. Benham, A. L. Carrión, R. Ciferri, C. W. Emmons, J. Lodder, D. S. Martin, A. de Minjer, R. L. Peck, P. Redaelli, M. Silva, J. W. Williams and F. T. Wolf. Foreword by J. G. Hopkins. Chronica Botanica Co., Waltham, Mass. 1947. xx + 236 pp. Frontispiece and 52 figs. $5.00.

This is Volume VI in the series *Annales Cryptogamici et Phytopathologi*. The fungi discussed are primarily those which cause human disease and several of the chapters are little or not at all concerned with what is commonly understood by biology. The editor recognizes this in his introductory chapter when he defines biology as "information from any category that can contribute to a fuller understanding of the life of the organism" and again when he states "a sound taxonomy is—an essential basis for any comparative endeavor on a group of organisms."

Following the introduction, there are chapters on the parasitic Torulopsoideae (Lodder and de Minjer), chromoblastomycosis (Carrión and de Silva), *Pityosporium* (Benham), *Coccidiodes* (Emmons), a survey of Italian work during the war years (Ciferri and Redaelli), the action of sulfonamides and antibiotics (Wolf), geographic distribution of systemic fungous diseases (Martin), nutrition and metabolism of pathogenic fungi (Nickerson and Williams), metabolic products (Nickerson), lipids of fungi (Peck) and respiration and fermentation (Nickerson). Each chapter has its separate bibliography and the illustrations and tables are numbered independently, but the work

is brought together by the three general indexes to authors, to organisms and to subjects.

As is to be expected in a volume of this nature, there is great unevenness in approach and emphasis by the different authors but this will not interfere with its usefulness. The editor has succeeded in bringing together a substantial body of information on human pathogenic fungi not readily available in English. The volume should be of great value to workers in the fields of medical mycology and fungous physiology and should furnish essential supplementary reading for courses in mycology.—G. W. MARTIN, State University of Iowa, Iowa City.

SEQUENCE IN LAYERED ROCKS.—A study of Features and Structures Useful for Determining Top and Bottom or Order of Succession in Bedded and Tabular Rock Bodies. By Robert R. Shrock. McGraw-Hill Book Company, Inc., N. Y. 1948. xiii + 507 pp., 397 figures (over 500 line drawings and 159 photographs). $7.50.

This book under the curious title *Sequence in Layered Rocks* may give one the preliminary idea that the emphasis is placed upon stratigraphy. Apparently the author has searched for a short, catchy heading and having found one qualified it with a longer descriptive subtitle. In reality, the book represents the exhaustive efforts of Professor Shrock to accumulate and present every conceivable situation and/or case both in present and ancient sediments which will give some clue to recognition of top and bottom in a stratal sequence. In addition, igneous and metamorphic rocks and their related structures are given careful consideration. The analysis is directed toward the field geologist. From a practical standpoint the importance of correctly diagnosing any circumstance involving the problem of overturned strata justly merits comprehensive treatment. In this respect the author is to be complimented on his keen observation in the field and digest of the literature in assembling this information and making it available.

The material is organized into eight chapters. The introduction conveys the simple, basic concept of stratification and its importance as a plane of reference followed by a discussion of the fundamental principles of correlation. The major portion of the book is devoted to a presentation and analysis of the various pertinent features of the three classes of rocks: sedimentary, igneous, and metamorphic. Three chapters are concerned with features of sedimentary rocks involving lithological, textural, and mineralogical sequences; upper- and undersurfaces of sedimentary beds, and internal features of this class. One chapter each is devoted to features in igneous and metamorphic rocks. Chapter VIII consists of 31 pages of bibliography representing 737 references which have been carefully annotated into a cross index. Eight of the entries are the author's original contributions.

The book is well illustrated with 397 figures which include 159 photographs and over 500 line drawings. Graphic representation of the data has been made more effective by the employment of combination photograph-line drawings and hinge-line block separations representing cast-mold counterparts. Out of all the photographs, only one, p. 67, fig. 30, is unintelligible. The important structural textbooks and articles dealing with criteria for recognizing top and bottom have been checked for page references and tabulated on pages 22-23.

Structural geology, sedimentation, stratigraphy, and petrology are nicely integrated to make this a handy classroom and field reference for those branches of geology.—R. C. GUTSCHICK, University of Notre Dame, Notre Dame, Indiana.

HUMAN HEREDITY. By Reginald Ruggles Gates. The Macmillan Company, New York. 1946. 2 volumes, xvi+1518 pp., 326 figs., 42 tables. $15.00.

Few biologists will wish to dispute Dr. Gates' statement that . . . "the time is now past when anyone can profitably suggest that little or nothing is known about heredity in man." Certainly no one will wish to dispute it after browsing through these two rather large volumes, which contain a systematic treatment of known and suspected hereditary traits affecting every functional system of the human body.

The author modestly states that "As regards literature, the subject is so vast that

only key references and some of the more important ones under each topic can be cited . . . it is hoped that few really important recent papers have been missed." The reviewer has not failed to find any "really important papers" in those fields with which he is most familiar. The chapter on blood groups, for example, gives a total of 289 literature citations. These include papers as recent as November 1945, which must have been inserted while the book was in proof. Bibliographies on other subjects are equally comprehensive. There are, for example, 82 papers cited on colorblindness, 133 on eye color and hair color, and 175 on hemophilia.

The work is enriched by the inclusion of much material from experimental genetics, both plant and animal, wherever Dr. Gates believes that this material may aid in the interpretation of the data of human heredity. Thus the work of Goldschmidt on intersexes in *Lymantria* is presented in connection with human intersexes, the work of Dobzhansky and his collaborators on genetics of natural populations of *Drosophila* is presented in connection with mutation rates, and the work of Beadle on the biochemical effects of mutants in *Neurospora* is presented in connection with genetic defects of metabolism in man.

The reviewer was interested in Dr. Gates' statement that in man most mutations are dominant because of "the general slackness of natural selection in civilized man." The reviewer does not know what proportion of human mutants may actually be dominant, but certainly many of the best known ones are recessive. Also, it is interesting to compare this statement with one of Dobzhansky: "The eugenical Jeremiahs constantly keep before our eyes the nightmare of human populations accumulating recessive genes that produce pathological effects when homozygous. . . . These prophets of doom seem unaware . . . that wild species . . . fare no better . . . than man . . ., and yet life has not come to an end on this planet. The eschatological cries proclaiming the failure of natural selection to operate in human populations have more to do with political beliefs than with scientific findings." While no one will wish to label Gates a "eugenical Jeremiah," it is clear that he attaches less importance to natural selection in man than does Dobzhansky.

The work is not entirely without defects. In the judgment of the reviewer, the most serious defect is the absence of a comprehensive treatment of the statistical methods which are so essential to the analysis of human pedigrees. Only the simplest methods are discussed. The results of studies using the more complex methods are presented, and references are given to the papers of Bernstein, Fisher, Haldane, Hogben, and others, so that one can easily refer to as much statistical literature as he may be able to digest. But the present work is, as Dr. Gates states, of necessity a reference work, and its usefulness would be greater if the statistical methods used in studies of human heredity were more completely presented.

The second chapter is entitled "General principles of heredity in man." This chapter is comprehensive in scope, taking up such recondite phenomena as penetrance and anticipation. The chapter will have its maximum usefulness as a review for biologists who have a good background in genetics. It assumes too much prerequisite information to have much value for those who have not had previous training in genetics. In condensing the general principles of heredity into the space of forty pages, some points have been left rather unclear. For example, the discussion of gene frequencies is based on mathematical discussion which is not particularly lucid.

When the various authorities cited on the mode of inheritance of a character differ, the reviewer would like to have the benefit of Dr. Gates' judgment in deciding which viewpoint is the best founded, however, he commonly does not give any indication of his judgment, as for example, in the chapter on allergy.

These criticisms are rather minor ones, and the work as a whole is very superior. Dr. Gates states that a work of this kind will necessarily be used for reference. The reviewer does not doubt that it will be the standard English language reference on human heredity for a long time to come. There are few men living who could have undertaken so comprehensive a treatment of human heredity. We owe Dr. Gates a debt of gratitude for having done it.—EDWARD O. DODSON, University of Notre Dame, Notre Dame, Indiana.

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